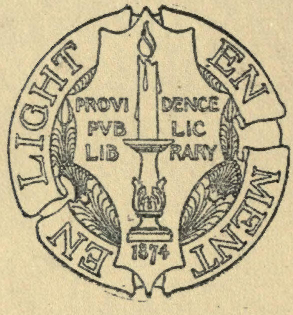

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FARMERS' BULLETINS

Nos. 1804-1825

WITH CONTENTS

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FARMERS' BULLETINS
Nos. 1801-1825

WITH CONTENTS

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Making LIME ON THE Farm

FARMERS' BULLETIN
No. 1801

U. S. Department of Agriculture

WHERE LIMESTONE is readily available it is often feasible for farmers, either individually or in groups, to quarry and burn or grind the stone for use on their land.

Limestone is sometimes almost pure calcium carbonate, but often it contains varying amounts of other materials. Before undertaking to develop a limestone quarry for the production of agricultural lime, the extent of the supply and the exact composition of the stone should be determined. To reduce the labor of hauling and spreading, it is desirable to have the quarry near the center of the area to be served.

Limestone may be reduced to the required fineness for use either by grinding or burning. Grinding limestone requires a considerable investment in machinery, and burning requires an abundance of cheap fuel.

Information in this bulletin has been drawn from various sources. Among them are Information Circular 6603 of the Bureau of Mines, which deals with methods and costs of quarrying limestone; Blaster's Handbook, published by E. I. du Pont de Nemours & Co.; and publications of the United States Bureau of Standards, and the State Agricultural Experiment Stations of Kentucky, Michigan, Pennsylvania, Virginia, and West Virginia.

Washington, D. C. **Issued May 1938**

MAKING LIME ON THE FARM

By N. A. Kessler, Formerly *Associate land clearing specialist, Bureau of Agricultural Engineering*

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INTRODUCTION

THE USE OF LIME for sweetening acid soils is almost a universal practice in humid regions. It is one of the big three—"lime, legumes, and livestock"—so effectively used in building and conserving soil fertility.[1] But the need for lime has never been met fully. To maintain proper amounts in the soils, it is estimated that the annual lime requirement of American farms would be about 32,000,000 tons, or 24 times the amount sold by commercial concerns in 1933. Fortunately, lime is one of the most common of all materials, occurring in nature as limestone, marl, marble, coral, oyster shells, and clamshells and in other forms.

The farmer can buy lime from commercial sources in the form and degree of purity desired; he can produce his own if he has a convenient supply of raw material; or he can cooperate with his neighbors in working a deposit. This bulletin deals with factors which should be considered by a farmer or a group of farmers before investing in equipment for obtaining lime from limestone or marl.

LIMESTONE

Limestone is usually found in more or less horizontal beds varying as to composition, hardness, weight, and weathering. Often it is so hard that explosives must be used to break it up, but sometimes it is so broken down by weathering that it can be removed with pick and shovel. It varies in color from light gray to dark brown or black. It is sometimes almost pure calcium carbonate, but some deposits contain magnesium carbonate in varying amounts.

LOCAL DEMAND

In the case of a farmers' cooperative quarry, or a private enterprise, the quantity of limestone which can be placed at a fair price in the locality is an important consideration, since the output needed determines the size and type of equipment to be used. Usually some information is to be found on the quantity of lime shipped into the area annually, and this figure can be checked against the recommendations of the county agent or the State agricultural college as to the requirements of the district. These requirements vary with the soils, but a rate commonly recommended is 1 ton per acre. In some sections fine limestone or lime is applied annually at rates of from 200 to 300 pounds per acre by means of fertilizer attachments on seed drills. Recommendations differ also as to the fineness of the limestone. Some soils respond satisfactorily to a ground limestone that passes a 10-mesh screen, whereas others react better to a finer stone.

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[1] See Farmers' Bulletin 921, The Principles of the Liming of Soils.

The price of lime varies with location, quality, and fineness of grinding and may be anywhere from 80 cents a ton at the quarry to $5 or more for delivered, finely ground material.

For the farm quarry the geographical limit of the probable market is usually fixed by the cost of hauling, generally by trucks. Sometimes the lime is spread directly on the field from the delivery truck. In Indiana and Illinois the ton-mile rate for hauling ranged from 3 to 10 cents and the spreading cost from 25 to 50 cents a ton. A commercial trucker in Indiana charges 35 cents a ton for distances up to 5 miles, 5 cents a ton-mile for each additional mile up to 20 miles, and 4 cents a ton-mile for distances beyond 20 miles.

THE QUARRY

Of primary importance in any lime-production operation is the quantity and quality of the available limestone. The individual farmer, perhaps, is not so much interested in the extent of his supply as he is in its quality, but a group of farmers should satisfy themselves that there is sufficient quantity before building a plant. A close estimate of the available material can be made by boring, probing, and digging. Some estimate of the thickness of the deposit can be made by examining exposed outcroppings, but drilling is the surest method, although expensive for small operations. The area of the formation in square feet, multiplied by the depth of the deposit, also in feet, will give the volume, and this figure multiplied by 168, the average weight of a cubic foot of limestone, will give the approximate weight of the deposit.

It is not uncommon for a farmer to rent or lease a quarry site, or for a number of farmers to do, as individuals, the work necessary to get out lime for their own needs from one quarry site. In such cases, a stipulated price is paid for each ton of rock taken from the quarry. The price is a matter of bargaining, but in a number of cases has varied from 2 to 5 cents a ton.

The quality of the limestone should be accurately determined before any funds are expended. Samples taken so as to be representative of the formation, should be analyzed by a chemist to determine the calcium carbonate equivalent. Rock containing 80 percent or more of calcium carbonate is good enough to warrant further investigation, but with less than that the advisability of proceeding further should be carefully considered. Larger quantities of low-grade than of high-grade stone must be used to obtain good results, and the labor in hauling and spreading is likewise greater. The more overburden, or material covering the deposit, the greater the cost of getting out the stone. For farm quarries, 3 feet is probably the maximum allowable overburden.

If there is a choice of locations, the quarry should be near the center of the area where the lime is to be applied; and it is desirable to have a good, firm road with easy grades leading from it. A good road out to a paved highway is almost a necessity for a neighborhood quarry.

STRIPPING

The removal of overburden is not usually a large operation on farm quarries. Where the job is not large, it is usually done with a drag scraper pulled by a team or tractor. Usually such work can be done with farm labor and equipment, with little cash expenditure; but if it is done by contract, the cost will vary from 15 to 50 cents a cubic yard of earth. For large operations fresno scrapers or power shovels are used but such heavy equipment is not adapted to the ordinary farm quarry.

DRILLING

In many cases the upper strata of the formation are weathered to such a degree that quarrying can be done by hand. Where the strata of stone are not clearly defined, are thick, or only slightly weathered, drilling and blasting will be necessary. Drilling may be done with hand or power drills. Choice of the two methods will depend on such factors as the thickness of the ledge, availability and cost of labor, the quality of the stone, and the capacity of the pulverizing machinery. Two inexperienced men with hand drills will drill a hole 1 inch in diameter in limestone at a rate of 1 foot in 40 minutes. A churn drill, a piece of drill steel 5 to 6 feet long, operated by one man, will drill faster than a hand drill. After a hole is started with a hand drill the churn drill is put in and is lifted and dropped.

Where quarry operations are on a large scale and the limestone formation is horizontal, or nearly so, well drills are used. Where operations do not warrant so large an investment, jackhammer drills are usually sufficient. These drills are operated by means of compressed air, electricity, or steam. If the grinding machinery is operated with steam, it is usually most convenient to use the steam jackhammer. Disadvantages of steam are the high heat loss by radiation and condensation, and the possibility of damage to steam pipes when the blasts are fired. Electricity has the advantage of being readily available at all times and the equipment is easy to move. Compressed air has the advantage of portability, not only in the quarry but from one quarry to another. The initial cost of power-drill equipment is relatively high for a small quarry operating only 6 to 8 months a year. In some localities compressors and jackhammers may be rented by the day.

A steam drill in a small quarry should average 60 feet or more of hole per 10-hour day. It is said that machine drilling is 5 to 15 times as fast as hand drilling and that in limestone there are records of instances where a foot has been drilled in 3 minutes. At an Indiana quarry where drilling was done with jackhammer drills using 1-inch hexagonal steel and six-point star bits, with one man doing all the drilling, the speed was 17 feet per hour. The holes were 10 feet deep, 2 inches in diameter at the top, and 1½ inches at the bottom. In another instance on medium-hard limestone, the drilling rate with a jackhammer was 120 feet per day.

The cost of machine drilling, not including depreciation on equipment, is usually much less than that of hand drilling. In several small quarry operations fostered by the State Rural Rehabilitation Corporation of West Virginia, the cost of gas, oil, and labor on compressed-air drilling operations varied from 2.8 cents to 3.5 cents a ton of ground limestone. The interest and depreciation costs for the compressor, for a ton of output, may vary widely depending on the amount of work done. Where the machine is in constant use the operation cost, not including depreciation, may be only a fraction of a cent a ton.

The spacing and depth of drill holes will vary somewhat in different quarries, depending on the height of the quarry face and the quality of the rock. Where the quarry face is 12 to 15 feet high the holes are drilled from 8 to 10 feet back from the face and from 6 to 8 feet apart. In some cases it may be advantageous to drill two rows of holes, staggering the second row and firing both at once. In a quarry near Milltown, Ind., in drilling operations on a 9-foot bench, the holes were drilled 10 feet deep, 6 feet back from the quarry face, and 6 feet apart. In a West Virginia quarry where the face was 30 feet high the holes were drilled 10 feet back from the quarry face and 10 feet apart. The best spacing for each quarry and sometimes for different parts of the same quarry must be determined by trial. If the quarry floor is to be kept level, care must be taken to drill holes to the same level, which should be slightly lower than the quarry floor. The correct depth can be determined after trial. Notes of conditions found when drilling are often of value when the holes are loaded.

Figure 1 shows the start of the drilling operations in a small quarry. The gasoline-driven air compressor is shown at the right of the picture.

BLASTING

After the holes have been drilled they should be tested before being loaded, to be certain that they are open to permit the free passage of the explosive.

The type of explosive to use is determined by the conditions in each quarry. Where the drill holes fill or partially fill with water, or where the stone is to be well shattered, it is advisable to use gelatin dynamite. Where the holes are merely damp, a moisture-resistant explosive should be used. In few cases will it be advisable to use an explosive less than 40 percent strength. The most commonly used size of dynamite cartridge is 1¼ by 8 inches. A ⅞- by 8-inch cartridge is also manufactured which may be used where the drill hole is less than 1½ inches in diameter. Large cartridges for drill holes 5⅝ inches in diameter or larger, used in large quarry operations, are on the market.

The amount of explosive necessary to blast down the rock will vary in the different formations. Where the limestone has been appreciably weathered the quantity of explosive necessary may be small. Where weathering has not been severe and the stone is tough, much more explosive may be needed, particularly when good breakage is desired. Since the breakage per pound of explosive varies from 3 to 6 tons, a common method is to assume a breakage of 3 or 4 tons per pound and load at that rate. After a number of trials the rate of loading for a particular formation may be determined. These trials will also help to determine the correct spacing for drill holes. Another method suggested is to fill the drill holes at least half full with explosive. In a West Virginia small quarry operation the loading rate is 0.4 pound per 1½ tons of stone broken down, or at the rate of 3¾ tons per pound.

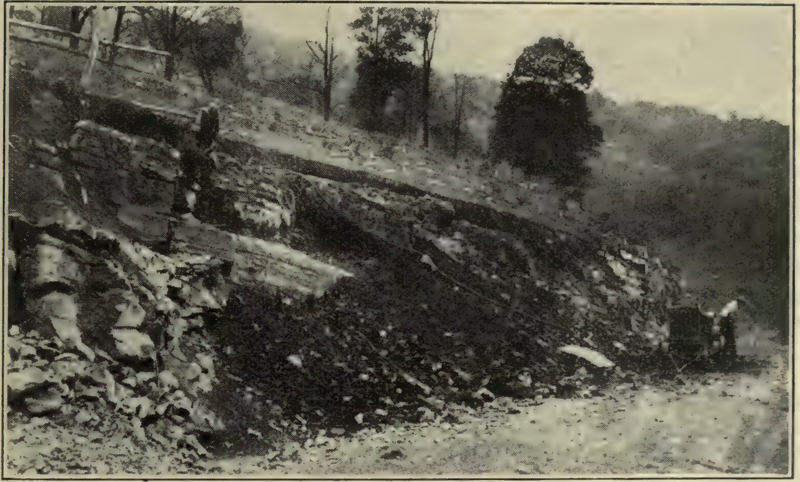

FIGURE 1.—Drilling holes in preparation for blasting. The overburden in the middle foreground is to be hauled away and used for highway fill.

In some quarries the drill holes are "sprung" so they may receive more explosive; that is, a small quantity of explosive is first used and the lower portion of the hole is then enlarged sufficiently to hold the necessary quantity. In bore holes of the size made by jackhammers, 2½-inch diameter or smaller, not more than six or eight 1¼- by 8-inch cartridges of dynamite should be exploded at one time because a heavier charge may cause the bore hole to cave or close up. Where slight caving occurs with light charges the bore hole can usually be opened up with a drill or steel bar. The effect of the explosions is to increase the bore hole in depth and diameter. The approximate size of the cavity can be estimated by dropping a short bar of wood attached to a rope. In making springing shots very little "stemming" (earthy material free of grit or stone) should be used, and there should be a sufficient interval between shots to permit of the cooling of the rock to avoid premature explosions when subsequent charges are loaded.

When the sprung holes are finally loaded for blasting, the explosive should be tamped firmly with a wooden tamping stick so there are no air spaces, since close confinement of the explosive increases its effectiveness. The escape of explosive gases through open seams, which reduces or nullifies the effectiveness of the explosive, may be avoided by dividing the charge. This is done by loading to a point below the seam, priming with an electric cap, and filling with well-packed earth to a point above the seam after which the loading of the hole is completed and primed with an electric cap. The use of electric caps permits simultaneous explosion of the separated parts of the charge. Caps and fuse cannot be used for this kind of shot since two charges primed with cap and fuse cannot be exploded simultaneously.

SECONDARY BLASTING

Occasionally masses of rock loosened by the first or primary blast are found to be too large to handle. They may be broken down with explosives by either blockholing or mudcapping, methods known as secondary blasting.

Blockholing consists in drilling a hole in the rock and loading it with a small charge of explosives. The depth of the hole for best results depends somewhat on the quality of the stone. As a trial it will be advisable to drill the hole to a depth of one-half the thickness of the stone. The quantity of explosive necessary to break a stone will depend on the size, toughness, and condition of the stone; that is, whether it was cracked as a result of the primary blast. For a trial shot the load suggested is one-half pound or less per cubic yard of stone. The amount of shattering will determine the accuracy of the load, and the succeeding loads should be decreased or increased accordingly. In loading, the explosive may be left in the wrapper, or it may be removed and poured into the hole. Where only a part of a cartridge is to be used, the wrapper only should be cut; the cut should not be made through the explosive nor should the cartridge be broken without cutting the wrapper. Where the explosive is removed from the wrapper and packed in the hole the wrapper should be packed over the charge after the cap has been inserted.

In mudcapping, the explosive is held against the boulder to be broken by a 6- or 8-inch layer of well-packed wet earth. As the explosion of dynamite has the same effect as the blow of a hammer, a common rule is to place the charge at the weakest point. Concave surfaces are favorable places for loading because they help to confine the explosive gases, whereas convex or rounded surfaces have a tendency to dissipate them. The explosive may be removed from the wrapper or used in the stick form. If removed from the wrapper, it should be thoroughly packed and the blasting cap imbedded in it before the mud is applied.

The quantity of explosive necessary can be determined after a few trials. A rule of thumb frequently used is to load at the rate of 1½ pounds of explosive per cubic yard of stone. Since the wet earth confines the gases for only a short time a high-velocity explosive is more effective than a low-velocity one. The charge necessary for a mudcap shot is appreciably greater than that needed for blockholing. Where jackhammers are available for the drilling, the blockhole method is better.

For blockholing and for mudcapping either electric or common fuse caps may be used as detonators, but the electric method of firing avoids hangfires, which are always dangerous, and the consequent loss of time waiting for the charge to explode.

SAFETY PRECAUTIONS

Dynamite and other high explosives and blasting caps are so dangerous, particularly in the hands of inexpert people, that they should not be handled or used except under the supervision of an experienced person known to be careful. Detailed instructions to meet all conditions and covering all methods and materials can not be given in this bulletin; but any one who plans to do blasting should obtain a handbook of instructions such as are put out by manufacturers of explosives. Even with the best of instructions safety demands the presence of an experienced man to supervise the job.

Explosives should be stored in well protected magazines, the caps stored separately from the dynamite, and unauthorized persons should be kept strictly away.

Caps should be carried in a box designed for the purpose—never in the pocket.

Straight dynamite is too sensitive to friction and impact for quarry blasting. Ammonia dynamite is less dangerous and less expensive. Gelatin dynamite is less easily set off by friction and not so liable to crumble and be spilled on the rock around bore holes.

It is highly desirable to fire charges with a blasting machine or electric detonator rather than with fuses, which frequently cause hangfires. A large percentage of blasting accidents are the result of hangfires. Electric blasting caps eliminate this danger. Since the number of charges to be fired at one time will be small, a blasting machine will furnish enough current. All charges should be connected in series, which reduces the possibilities of misfires and the consequent danger that quarrymen will hit a charge with a pick or other tool.

Tamping of charges should always be done with a wooden tamper with no metal on it.

Never handle explosives roughly or slide packages over each other or along the floor. Always know where explosives are, and be sure that the place is safe from tampering, fire, or from rock fragments thrown in blasting.

One person should have absolute charge of the blasting and care of the materials. When blasts are about to be fired all workmen should be required to respond to a signal so the blaster may be sure they know a charge is to be fired and that they are far enough away.

In limestone grinding, discussed in the next section, precautions should be taken to prevent injuries to workers. Each man should be careful for himself and do all possible to protect others. Exposed moving parts of machinery liable to cause injury should be covered or shut off from close approach.

If all equipment and tools are kept in good condition, danger of accidents will be less.

Before using explosives or operating grinding machines, find out about State and local laws and regulations bearing on such operations.

GRINDING

In grinding agricultural limestone a combination crusher and pulverizer or pulverizer alone may be used. Each has advantages and disadvantages.

The jaw type of crusher is most common for primary crushing in small operations. Where it is operated before the pulverizer, the quarried stone need not be so small as would be necessary if the stone were fed directly to the pulverizer. In working formations of tough limestone where the strata are thick or the lines of cleavage are not distinct, the use of a crusher may save in drilling and explosives cost because the stone need not be shattered so much as for feeding to the pulverizer. Some labor also may be saved. On the other hand, the purchase of a crusher will increase the machinery investment and the overhead costs, and power will be required for operation. If both crusher and pulverizer are to be used, they should have about the same capacity.

In weathered limestone good breakage is possible with little or no explosive, and a crusher is not needed. With a little sledge-hammer work the stone can be fed directly to the pulverizer. Pulverizers, depending on size, will take stones from the size of a brick to stones weighing 75 pounds or more. Feeding quantities of small stones to the pulverizer may clog it, while continuous feeding of big ones places an excessive strain on the machine.

The hammer mill is the type of portable pulverizer most used. It ranges in price from $500 to $3,000 or more, and in capacity from 3 to 12 tons per hour. Fineness of grinding, quality of stone, and the power used, affect the rate of grinding. The capacity of the machine and the amount of equipment purchased should be based on the number of farmers in the cooperative, or on the probable demand from the community for ground limestone from the quarry. It would not be advisable to buy expensive equipment if the demand is only sufficient to keep it in operation a short time each year.

The fineness to which a pulverizer may grind lime is limited by the spacing of the screen bars. It may vary from the maximum that will pass the screen bar to very fine. Since the fineness is also determined somewhat by the velocity at which the hammers revolve, it is advisable to apply sufficient power to maintain the speed recommended by the manufacturer, which is also necessary if the productive capacity of the machine is to be maintained. Speed much greater than that recommended by the manufacturer, however, is dangerous.

Power is generally obtained from a tractor. This is convenient because the tractor may be also used to draw the pulverizer from one location to another and may readily be obtained on a rental basis. Stationary engines are sometimes used, and in some localities light steam boilers and engines in good condition that have been displaced by gasoline motors may be purchased at a reasonable price. Before purchasing steam equipment, however, State laws governing its operation should be learned so that all requirements, such as hiring a licensed engineer, are fulfilled. In any case the boiler should be inspected by a competent person.

Grinding equipment may be located at such distance from the quarry that stone may be taken to it by means of wheelbarrows, by a quarry car, or by trucks or wagons. The distance between the quarry and the pulverizer should be kept as short as feasible. Where the distance is short the principal expense will be for wheelbarrows and labor. For longer distances there will be the cost of operating a small railroad car or truck, but fewer men will be required and the pulverizer will not need to be moved so frequently. Where trucks or wagons are used, the hauling distance may be somewhat greater than is practicable for wheelbarrows or quarry car.

It is possible to so regulate grinding that no storage is necessary, but it is convenient to have at least a small storage bin for the ground limestone. This may be of the temporary, transportable type shown in figure 2, or all-metal bins may be bought. In all but the simplest plants, one or more elevators are necessary to facilitate loading or storage.

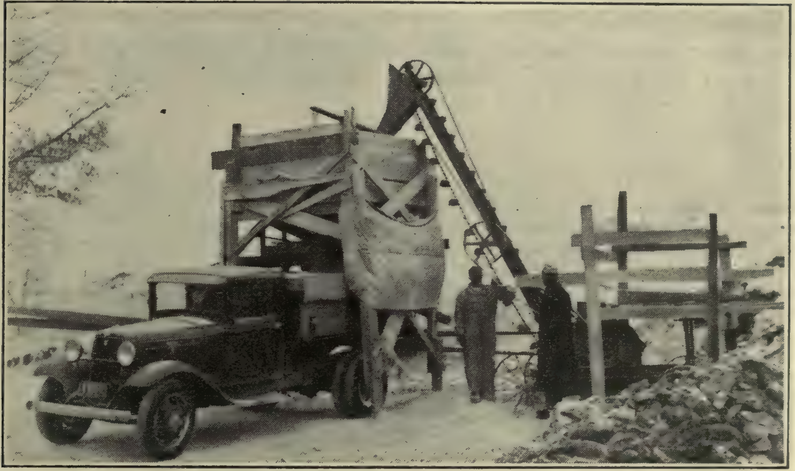

FIGURE 2.—Temporary bin with pulverizer. Note the cloth hung on the side to prevent the fine limestone from being blown by the wind.

MAINTENANCE OF EQUIPMENT

Because of the heavy stresses on the machinery the wear and tear is necessarily rather high. The wear is greatest on the hammers of the pulverizer because they are in almost constant contact with the stone. While the extent of wear depends largely on the quantity of stone pulverized, the quality is also a factor. The presence of abrasive materials in the stone will materially increase the rate of wear, particularly of the hammers. Under average conditions, from 1,800 to 2,000 tons of limestone can be ground with one set of reversible hammers. Hammers range in price from $20 a set, up, depending on the machine. Under average conditions screen bars will wear approximately two to three times as long as hammers, while liners and breaker plates may wear from five to six times longer. Records kept by the Kentucky Department of Agriculture indicate a maintenance cost for portable pulverizers of approximately 3 cents per ton of ground limestone, but the general average probably is about 4 to 5 cents per ton.

SUGGESTED PROCEDURE PRELIMINARY TO FARM LIMESTONE GRINDING

The general procedure to be followed on a farm for the purpose of producing agricultural lime for a group of farmers is: (1) Determine the amount of lime required annually. (2) Determine the probable saving by comparing the cost of home-produced lime and the cost of lime obtained from commercial producers, taking into consideration the transportation charges. (3) Determine the extent of the limestone formation on the farm by boring, probing, or digging. (4) Determine the quality of the limestone by chemical analysis. State agricultural colleges have facilities for doing this work. (5) Get prices on limestone-grinding equipment. (6) Before buying an outfit try to have a demonstration of how it will work with the particular stone to be crushed. (7) Figure costs of producing ground limestone of the fineness recommended by the State agricultural college.

To determine the cost of producing ground limestone such factors as cost of equipment, depreciation, interest, labor, and other items should be considered. For example:

Limestone formation	8 feet thick.	
Overburden	1 foot thick.	
Ground limestone (annual demand)	140 tons.	
Volume of overburden to be removed	212.5 cubic feet.	
Volume of rock to be ground, approximately	1,700 cubic feet.	
Time required to strip the quarry, 1 man and 2 horses	3.5 days.	
Cost of stripping (3.5×$4—cost of team and labor[1])	$14.	
Number of men for quarrying and pulverizing	5.	
Cost of pulverizer with 2 ton per hour capacity	$625.	
Estimated life	20 years.	
Hours worked annually	70.	
Fixed charges:	*Per hour*	*Per ton*
Depreciation (20 years of life, estimated)	$0.41	
Interest (average annual investment[2])	.22	
Total	0.63	$0.32
Other costs:		
Tractor	.75	.38
Labor, 5 men at 25 cents per hour	1.25	.63
Repairs at 4 cents per ton	.08	.04
Stripping quarry	.20	.10
Royalty	.10	.05
Total	3.01	1.52

[1] Man labor, 20 cents an hour; horse labor, 20 cents an hour.

[2] Average annual investment $=\frac{\text{first cost} \times (\text{years of service}+1)}{\text{years of service} \times 2}$

The cost of the pulverizer equipped with wheels and elevator is the average price of a number on the market. About 18 horsepower is required to operate the pulverizer; this can be furnished by the average farm tractor equipped for belt-power work. This additional work helps to reduce the operating cost of the tractor for both the farm and the pulverizing work.

It will be noted that the calculated cost per hour of producing ground limestone, except for royalty and repairs, will remain the same regardless of the quantity of ground limestone produced. It is therefore evident that the planned rate of production must be maintained if the cost is to be held within the estimate. If production per day can be increased beyond the point originally planned, the cost per ton will be less, or the same result will be obtained if the plant is operated for a longer period annually. Where larger operations are under consideration all factors involved must be studied carefully. While larger operations will permit lower cost production when carried on under the proper conditions and in an efficient manner, it is also true that the losses will be greater when operations are carried on under adverse conditions or in an inefficient manner.

The ownership of units may be of different kinds. The machinery may be purchased by a group of farmers and operated at one quarry, or it may be operated on the premises of the different members of the group where limestone is available. In either case the members of the group may comprise the operating crew. The ownership may also be held by a cooperative organization which operates the equipment during the lime-grinding season, and the labor employed may or may not be farmer members. Still other systems of ownership and operation may be adaptable to a given locality.

BURNING

Burned limestone is used extensively on farms and is obtained by heating or burning high-calcium or magnesium limestone to drive off carbon dioxide gas. The addition of water to the portion remaining changes it to slacked lime. Under favorable conditions the farmer may burn limestone economically for his own use. While the cost of burning adds considerably to that of the raw limestone, it gives a product with about twice the neutralizing power of the original stone.

When limestone is burned, carbon dioxide is driven off, and calcium oxide or calcium and magnesium oxides remain. The quality of the lime depends on the quality of the stone used and the care taken in burning it. Limestone can be burned by one farmer or by a group of farmers with little or no investment in equipment, since the only requirements are labor, low-cost fuel, and low-cost, good-quality limestone.

The amount of heat required to burn limestone depends on its character and varies from 1,400° to 2,200° F. Greater heat is usually required for calcium limestone than for magnesium limestone. Where such impurities as silica, alumina, and iron are present, the temperature must be kept below their melting points to prevent the formation of slag and the making of "dead burnt" or "overburnt" lime. About 2 percent of silica will not affect the burning of the stone, but the alumina and iron content should not exceed ½ to 1 percent. Less heat is required to burn a dense, fine-grain stone than one which is coarsely crystalline and porous. In burning, a high temperature may be used for a short time or a lower temperature for a longer time. The more nearly the amount of heat used approaches the minimum required, the better the quality of the lime.

Temperature measurements made of the heat developed while a lime stack in Pennsylvania was being burned indicated that on the sixth day of burning the temperature near the top of the stack was 518° F. and the highest temperature, 840°, was at the bottom of the stack near the outside. Seven days later, the temperature at its highest intensity having become well distributed throughout the stack, the color of the mass for a distance of several feet inward was a bright cherry red, indicating that the temperature had been about 1,500°. The analysis of the stone burned was:

	Percent
Carbonate of lime	51.72
Carbonate of magnesia	41.75
Iron and aluminum oxide	1.06
Sand, clay, etc	5.02
Undetermined	.45
	100.00

In burning limestone for agricultural uses either the stack or kiln method may be used. Both methods have strong advocates, but there seems to be little reason, except personal preference, for the selection of one method over the other under normal conditions.

STACK METHOD

A method used in Kentucky (fig. 3) is to first lay down green logs about 1 foot in diameter and 16 feet long with 2-foot spaces between them, so as to make a base 12 to 16 feet wide. If full-length logs are not available, shorter logs, placed end to end to make up the necessary length, may be used. The 2-foot spaces are filled with dry wood for starting the fire. Only green logs are used in the foundation because they do not burn readily and will hold the lime stack off the ground so a better draft will be obtained.

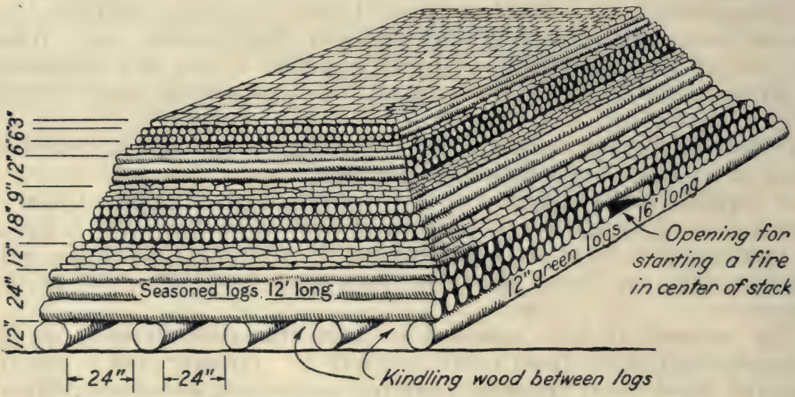

FIGURE 3.—A method used in Kentucky for laying a lime stack.

Across the foundation logs well-seasoned logs, as large as can be obtained, are laid to a thickness of 2 feet. The logs are placed as close together as possible. A space 3 feet square is left in the center of this layer and filled with well-dried kindling wood. A space 20 inches wide is left through the 16-foot dimension of the stack to permit igniting the wood in the center since it should burn from the center outward. This 20-inch space is omitted in the succeeding layer.

Stones varying in size from 1 to 6 inches in diameter are piled on the layer of seasoned wood to a thickness of 1 foot, or one-half the thickness of the logs beneath. As more layers of stone and wood are added, each succeeding layer of wood is decreased 6 inches in thickness and 2 feet in width from the layer preceding, piled at right angles to it, and covered with stone to a depth one-half the thickness of the logs beneath. The stack may be 8 feet high. The fire is started by igniting the dry wood in the 2-foot spaces in the foundation and in the 3-foot square space at the center of the second layer.

A stack built in Pennsylvania had first a lower layer of apple wood, trunks and limbs, arranged radially from the center with narrow air spaces between the pieces to give draft. Over the apple wood a layer of old chestnut fence rails was laid, and over these three wagon-loads of dry corncobs were evenly spread. The diameter of this foundation was 32 feet. About the center of the stack a layer of white pine kindling 3.5 feet in diameter and 15 inches deep was spread, and in the midst of this kindling a flue made from 6-inch chestnut boards was placed. The flue was held in place by wooden braces.

The stone was laid in successive layers, the size and thickness of the stone increasing with each layer. The thickness of the first layer was 3 inches, and the thickness increased approximately 2 inches with each layer to and including the fifth; from there on, approximately the same thickness was maintained for the remaining layers except the tenth (the last), which was made 2 inches thicker. The stone in the first layer measured 3 inches in diameter; that in the second and third layers, 4 inches; that in the fifth and sixth layers, 6 inches; and in the remaining four, approximately 7 inches. Each successive layer was covered with just enough coal to form a continuous black surface.

The lowest layer was 30 feet in diameter so that the wood, or foundation, projected 1 foot around the entire stack. The higher layers were of lessening diameter so that when the stack was completed the top was about 10 feet in diameter, and the vertical height was 10 feet. When the final layer was completed, coal was banked on the sides of the stack, and over this was placed a well-firmed layer of earth 10 inches thick. No earth was packed over the wooden foundation layer.

The kindling at the bottom of the flue was ignited after being wet with kerosene. The flue was left open 6 hours; after that it was covered with a flat stone over which earth was thrown. The uncovered wood foundation layer admitted sufficient air to keep the fire burning. When the foundation layer had completely burned, earth was thrown around the base of the stack to cut off the bottom draft. All openings which appeared in the soil covering were promptly closed. The total actual burning time was 11 days, after which the stack slowly cooled for 9 days, when the earthen cover was removed and the heap exposed to further cooling for 2 days.

The total amount of limestone burned was 307,964 pounds, and the total weight of the lime, including coal ashes, was 188,760 pounds. Deducting 4,000 pounds for the estimated weight of the coal ashes, there was 184,760 pounds net of lime. The cost of production was 9.2 cents a bushel, or $2.33 a ton of 2,000 pounds, when man labor was 17.5 cents an hour, team work 40 cents an hour and coal $2.60 a long ton (2,240 pounds) f. o. b. freight station. There was no cost for quarrying, the stone having been delivered at the burning site; however, it was necessary to break the stone further to make it of suitable size for burning.

In West Virginia a method similar to that in Pennsylvania is employed. Approximately 3 cords of seasoned wood are used to make the base of a 100-ton stack. In the center a large log is placed upright, and from it in the base four logs of 2-foot diameter are placed radially, at right angles to each other. The openings left by these logs when burned provide draft until the firing has been properly distributed, after which one or more may be stopped up. The stone is broken to a size not to exceed 6 by 8 by 10 inches, placed in layers 12 to 14 inches thick, and each layer covered with about 3 inches of coal. Alternating layers of stone and coal are placed until the stack reaches a height of 10 feet. The entire stack is covered with earth 2 feet thick at the base and gradually tapering to 1 foot at the top.

After the stack has burned for 3 or 4 days, or when the stone becomes a dull red, all openings are sealed. As the burning progresses, all crevices or openings which develop are covered with earth. The average burning time is 9 to 11 days and the cooling time 2 weeks unless there is rain, in which case the cooling time is less. To examine the progress of burning, a hole is shoveled in the clay coating. During the early stages of heating the stone appears to be a dull red and later, as calcination takes place, the color changes to white, with the unburned core or bone in the center of the lump appearing violet red in contrast to the white heat of calcined stone. When the violet-red color has disappeared, complete calcination has occurred.

These stacks are built near the quarry. No explosive is necessary in quarrying because of the weathered condition of the stone. In constructing a stack 10 feet high five men can place 45 tons of prepared stone and the necessary coal per day up to 6 feet in height. Above 6 feet the tonnage per day decreases 50 percent. To complete a 100-ton stack requires the labor of five men for 3 days after the rock has been prepared, and an additional day for five men is required for clay banking and firing. It is advisable, however, that a stack of 100 tons or more be built up to a height of 10 feet, and when possible 15 feet, in order to secure efficient and complete combustion by utilizing the hot gases that pass upward through the stack. One ton of slack, or fine coal, is required to burn 3 tons of raw limestone to produce 3,540 pounds of quicklime, or 5,310 pounds of hydrated lime. If higher-grade coal is used, 1 ton of fuel will calcine 4 tons of raw stone.

KILN METHOD

A method of kiln construction used in Virginia (fig. 4) is as follows: A location close to the quarry is selected, preferably on the side of a hill. An excavation is made 10 feet into the hill and to a depth of 7 feet. The width of the kiln is 8 feet at its greatest breadth, sloping gently downward toward the front on the bottom. A trench 18 inches wide and 12 inches deep is dug through the center at the base. Across this trench pieces of old iron castings are placed to serve as a grate. The front and side walls of the kiln are built like a retaining wall. Sometimes the rear walls are built of rock, but usually the sides of the hill answer the purpose. The general plan of the kiln is oval, both at the base and top.

Over the grate in the center is placed a layer of coal lumps too large to pass through the opening. On top of this is placed limestone rock, which may vary from 6 inches to 12 inches in diameter. The kiln is then filled by placing alternate layers of coal and rock. An opening large enough to serve as a flue is left in the rear at the top. When the kiln is filled, it is covered with a layer of flat rocks, and the front is closed with rock and sealed with mud. Sufficient kindling is placed in the trench to ignite the coal. The fire usually burns for 2 to 3 days, and 3 to 5 days are allowed for cooling.

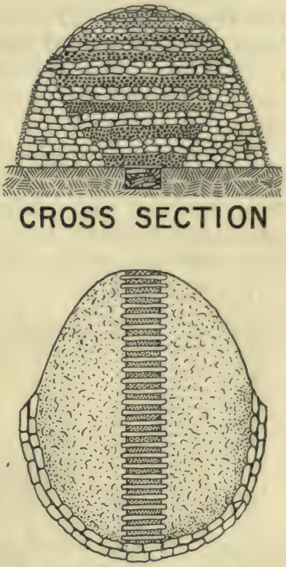

Figure 4.—Cross section and plan of lime kiln used in Virginia.

The services of one man from 8 to 10 days are required to build and operate the kiln. In a kiln of this size 100 bushels of coal are used with 300 bushels of limestone.

A method used in Kentucky is to excavate 15 feet into a hill so that the top of the bank in the rear is 6 to 10 feet above the bottom of the pit. The back and sides are made straight and vertical and the bottom level.

The foundation for the "eyes," or fireboxes, is made by laying large flat limestones in the bottom of the pit according to the dimensions shown in figure 5. When the foundation has been laid, construction of the eyes is started at the rear and completed at the front (fig. 5). Smooth, flat stones are used for this purpose. The eyes, which take the form of a triangle 36 inches high, are formed by extending each stone 2 or 3 inches over the one below. Instead of using a keystone, a flat stone about 6 inches thick and 2 feet long is laid across the gap at the top. All joints should be broken, and occasionally a long stone is placed across the span between the eyes to tie them together.

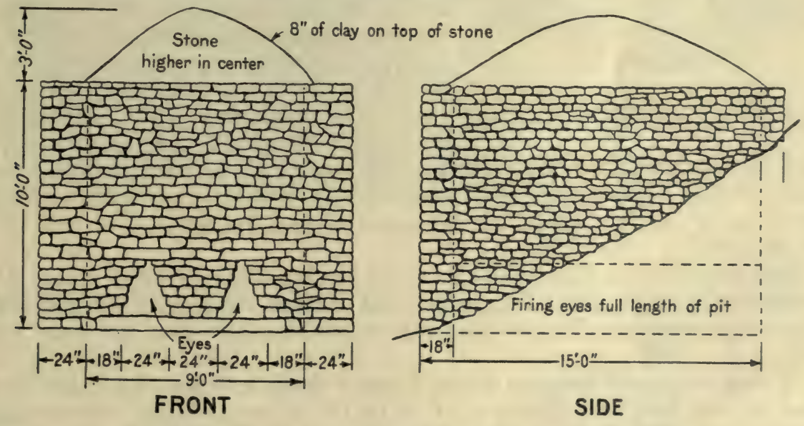

Figure 5.—Side and front views of a lime kiln in Kentucky.

After the eyes are completed and before the outside walls are built, the pit is filled to the top with broken stones, the heavier pieces of which are placed directly over the eyes and the smaller at the top of the kiln. Filling of the kiln with broken stone is continued as the walls are built.

The front is built to a height of 10 feet. The side walls are built on the ground at the outside of the pit, extending up the slope from the front wall. The front and side walls should be of equal height, level at the top, and tied securely at the corners. A back wall is not built unless necessary. The outside walls are plastered with wet clay and the top of the kiln covered with at least 8 inches of wet earth to retain the heat.

For use in firing, well-seasoned wood is essential. A slow fire is first kept for 12 to 14 hours to season the stone, after which the fire is kept as hot as possible. A flue is not necessary as sufficient draft is produced through the rock and earth. A heavy black smoke escapes from the top of the kiln while the stone is burning. After this has ceased a crowbar is driven into the top to determine when burning is complete. Seven days and nights of continuous burning is required for the average kiln.

A method of kiln burning somewhat similar to that just described is used in Pennsylvania. A rectangle 10 by 13 feet is first laid out. Two eyes are constructed, as previously described, under each of which has been dug an ash pit 16 inches wide and 12 inches deep. The eyes, across which irons are laid to act as a grate, are 2 feet wide and 3 feet high. When the eyes have been completed, the kiln is built up solidly to a height of 8 or 10 feet with stone 4 to 8 inches in size, the larger of which are placed closest to the eyes and the smaller farther away; the top 6 inches of fill is of stone not much over 2 inches in diameter. The thickness of stone between the eyes and the side and rear walls should not exceed 2 feet, and fillets of earth or of other stone 1 foot high and 1 foot wide should be put in the corners of the base, as shown in figure 6, because the heat from the eyes will not be effective at those points.

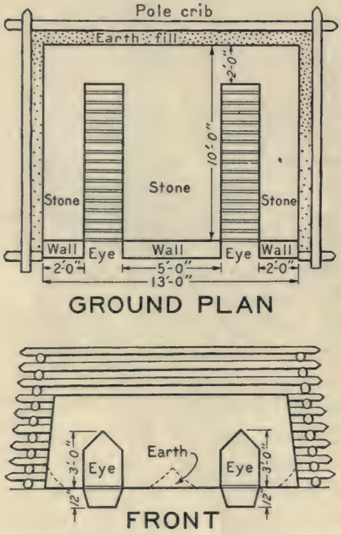

FIGURE 6.—Ground plan and front view of a lime kiln in Pennsylvania.

The face of the kiln is next walled up to a height of 5 feet with some stone other than limestone and bound with clay or mortar. Openings corresponding to and sometimes smaller than the eyes are left in the wall.

A crib work of notched poles is next built around the sides and back of the kiln at a distance of 15 to 18 inches and the intervening space filled with earth to retain the heat. The crib is continued on the face above the top of the wall and backed with earth. The top is left open.

Fires are kindled on the grates in the eyes and fed with well-seasoned wood for from 3 to 5 days and nights, depending on the wood, draft, and the weather. The eyes are closed with sheet iron when not being fired, but draft must be furnished through the ash-pit. When the burning is completed and the kiln has cooled, the lime is taken out from the rear after the removal of the poles and earth. The kiln may then be built up again and fired.

MARL

There are several types of marl. That deposited in low depressions is usually the most costly to dig. In marshy locations the deposit may be covered with a layer of muck or peat varying in thickness from a few inches to several feet, and water may cover part or all of the site. In one county in Michigan the State geological marl survey showed the ratio of average depth of overburden to depth of marl for beds workable by hand to be 1 to 6½, and for deposits workable with power equipment the ratio is given as 1 to 8¾. The surface is sometimes covered with tough marsh grass, which makes the removal of overburden difficult.

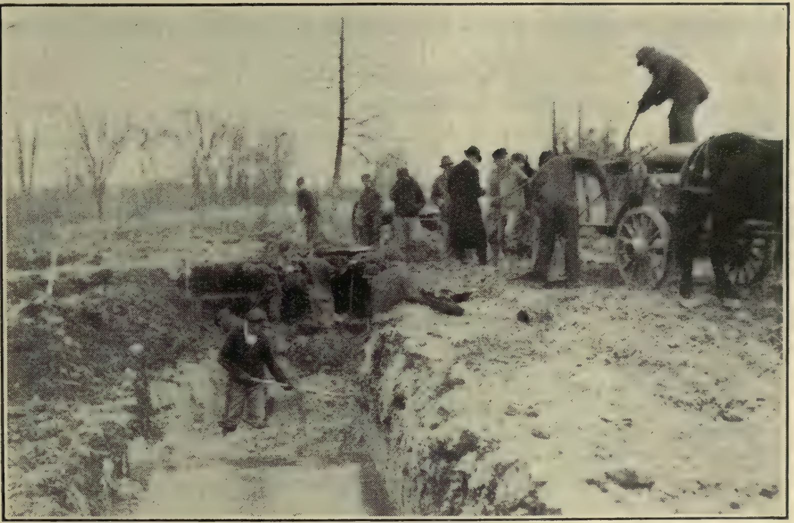

FIGURE 7.—Digging lowland marl in a dry season.

Saturated marl weighs about 50 percent more than an equal volume of water; when the marl is air-dried, a considerable loss of water as well as of volume takes place. Measurements of piles excavated indicate that shrinkage as a result of air drying may be 25 percent or more. The unit of measurement for this type of marl is the cubic yard.

Marl is soft, spongy, and extremely sticky. The sticky property has made its excavation with the slip scraper and other small equipment practically impossible, but it can be readily handled by power machinery.

In seasons of drought, marl deposited in low marsh areas may be dug by hand, as shown in figure 7. In 1931, owing to lack of rainfall, about 80 percent of the marl pits in Michigan were worked by hand. When wet marl is soft the shovelers are likely to sink into it somewhat. Under these conditions shoveling is difficult and slow. It has been estimated that in lowland marl a man can dig an average of 0.4 cubic yard per hour.

More lowland marl is dug with machinery than by hand. Some marl has been dug by the larger commercial outfits on a per yard basis, but this is feasible only where considerable quantities are dug. In the winter of 1934–35 a number of commercial units dug lowland marl at prices from 8 to 20 cents per cubic yard. In normal times the contract price would probably be nearer 50 cents per cubic yard for large quantities.

Because of the smallness of the operation, farmers who have marl deposits desire a small, low-cost excavating unit. Such a unit has been designed by the Agricultural Engineering Division of Michigan State College of Agriculture, the important feature of which is a ¼-yard bucket especially constructed to dig marl. This unit is a slack-line cableway rather than a dragline, and the power used may be a team or tractor. The estimated capacity of this unit is 40 cubic yards per day at a cost of 15 cents to 25 cents per cubic yard.

As an illustration of marl-digging costs where equipment must be used to dig it out of a lake bed or other wet location, assume that the type of equipment to be used is that developed for the purpose in Michigan.

Cost of the marl-digging equipment including the Musselman bucket	$210.
Estimated life	10 years.
Time worked annually	120 hours.
Quantity dug per hour	3 cubic yards.

	Per hour operation	*Per cubic yard*
Fixed charges:		
Depreciation (10-year life, estimated)	$0.17½	$0.06
Interest at 7 percent=$9.09 per year	.07	.02
Operating cost:		
Labor, 2 men at 20 cents per hour	.40	.13
Team, 4 horses, at 10 cents per hour	.40	.13
Removing overburden	.22½	.08
Royalty	.60	.20
Repairs (estimated)	.06	.02
Total	1.93	.64

The item of 2 cents per cubic yard for repairs, while estimated, is believed to be ample. It is also probable that the life of the equipment is greater than indicated since the wear and tear on it is small as compared to that on equipment for crushing and pulverizing limestone. The cost per hour of digging marl, except for royalty and repairs, remains the same regardless of the quantity dug while the cost per cubic yard will vary with the quantity dug per hour. As with the lime-grinding operations the greater the production per hour the lesser the cost per unit of measure and conversely the lesser the production per hour the greater the cost per unit of measure. It is therefore important that the production be maintained at as high a rate as possible if the cost is to be kept low.

Upland marls are generally dug by hand, and the rate of digging is about 1 to 1½ cubic yards per man-hour. In some cases these marls contain considerable moisture and in others little if any. In the former case digging may be started with very little preparatory work except for the removal of the overburden, while in the latter the removal of overburden must be followed by plowing to loosen the marl. In Kentucky the suggested procedure is to remove the overburden covering the marl bed to the greatest practical width and length to provide for future development. Plowing, which is done across the slope, should be done shortly before loading because the marl can be handled better then than later when it has absorbed moisture. The use of a portable chute is also recommended because it is the most efficient method of loading marl; the cost of construction is low; the chute is easily moved from one bed to another, does not have to be adjusted to the height of wagon or spreader, and can be easily moved to various parts of the marl bed to save labor in loading. The cost of excavating and spreading marl of this type is about 50 cents per ton. It is estimated that one man can dig and spread 12 tons of marl a day if the hauling distance is not more than one-fourth mile.

In one West Virginia project upland marl is dug by means of a gasoline shovel, and the larger pieces are screened out. Shovel rental is $1.50 an hour including gas, oil, and operator. Under favorable conditions this shovel will handle 12 tons an hour. The cost of shoveling is approximately 15 cents and the screening costs approximately 11 cents per cubic yard. These costs vary somewhat in different locations.

SPREADING LIME

The farmer may haul the lime in his own truck, or he may arrange with a truck owner to do the hauling or to do both the hauling and the spreading. In the last case the farmer is relieved of a task usually distasteful, requiring considerable time which could be used to good advantage in doing other farm work, particularly in the rush season. It is probable that a truck driver experienced in this sort of work will spread the desired quantity per acre more uniformly over the field than would the average farmer who does this work only now and then. Drivers who haul lime say that a truck having dual wheels can spread a 6-ton load on plowed ground that is not too wet. They also report that it requires nearly as much time to unload the lime at one point on the farm as to spread it on the field.

The spreaders used range from those of a home-made type costing only a few dollars to manufactured types, such as that shown in figure 8, costing up to $350. The number of men required to spread lime ranges from one to three, depending on the spreader, including the driver of the truck or wagon.

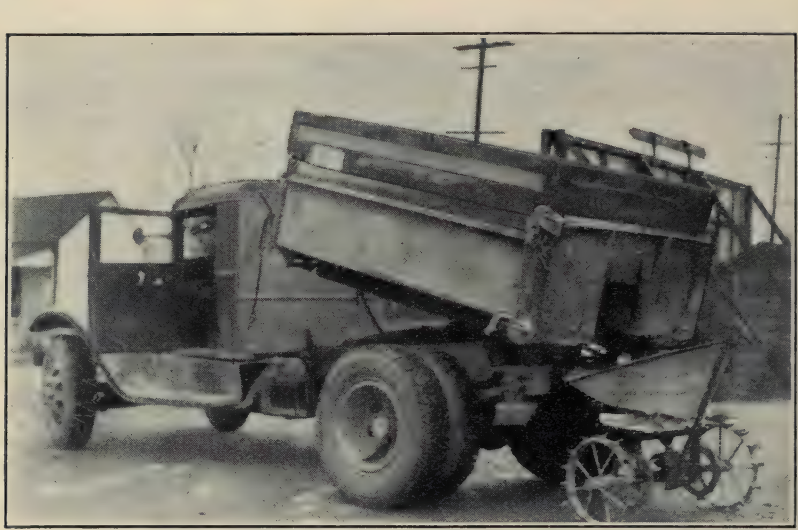

FIGURE 8.—A light lime spreader attached to a truck.

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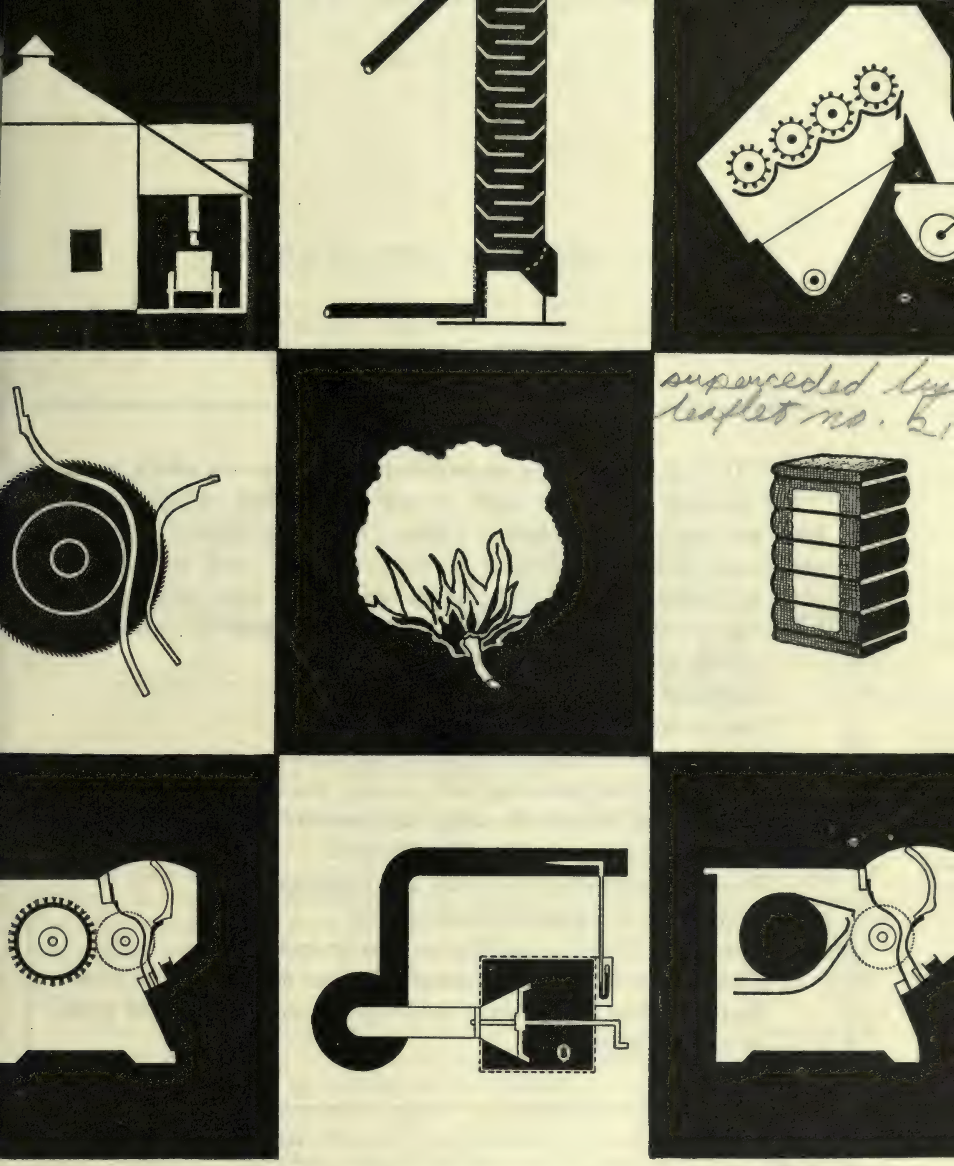

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MODERNIZING COTTON GINS

FARMERS' BULLETIN
No. 1802

S. DEPARTMENT OF AGRICULTUR

COTTON GINNING is undergoing improvements which make it possible to reduce costs, better the quality of the ginned lint, and increase its market value. Both the grower and the ginner are benefited, directly or indirectly, by each advance in ginning practices and each improvement in equipment. The following are the most important features of a modern cotton gin:

A fireproof single-story building.
Adequate illumination and ventilation.
Cotton-drying equipment.
Cleaners and extractors to serve the regional needs.
All-steel cotton handling and ginning machinery.
Ball-bearing or roller-bearing mechanisms.
Improved piping and fan installations.
Pure-seed protection by belts and other means.
Seed scales and platform bale scales.
Metal seed bins for loading wagons or trucks.
All-steel press, with mechanical tramper and hydraulic ram.
Ample shelter and storage facilities for seed cotton and seed.
Attractive premises.

Washington, D. C.

Issued July 1938
Slightly revised February 1939

MODERNIZING COTTON GINS

By CHARLES A. BENNETT, *senior mechanical engineer*, and T. L. BAGGETTE, *assistant agricultural engineer, Bureau of Agricultural Engineering*, and F. L. GERDES, *cotton technologist, Bureau of Agricultural Economics*

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INTRODUCTION

IMPROVED COTTON-GINNING PRACTICES and better ginning establishments improve the quality of ginned lint, aid in keeping planting seed pure, and tend to increase profit. Many public ginners, as well as farmer-ginners, would modernize their establishments in whole or in part if they were assured that they were taking the right steps and that they would be actually following the recommendations of State and Federal agencies working toward these improvements.

In the case of existing cotton-ginning establishments it is frequently a question whether to remodel or rebuild completely. This question can best be answered by asking other questions. Is the present equipment still serviceable and in good condition? If so, is it adequate for the present requirements of conditioning, cleaning, and extracting? Will the cost of modernization of either equipment or buildings be less by remodeling than by entire replacement? Which will attain the main objectives with regard to both public and private interest? Is the present or proposed establishment economical in operating the equipment for cotton handling, ginning, and disposal of products?

This bulletin is intended to help ginners and farmer-ginners to answer these questions and to plan according to the needs of their own individual circumstances and those of their communities.

APPRAISAL OF EXISTING GINS

Consideration must be given to the location of the gin on the farm or in the community. Frequently conditions have so changed that gins are now in very poor locations. Accessibility to roads and transportation facilities and the proximity to competitors may have changed, in a large measure, since the original establishment of the ginning plant so as to affect materially the present value of the plant in many instances.

A simple sketch of the property showing the relative positions of the several buildings and accompanied by marginal notes describing the territory served, the number of bales of cotton ginned over an average period, the increase or decrease in cotton acreage in the community, and other influencing factors, will be of assistance in making a complete appraisal.

The inspection of the buildings on the property should be made only by a person experienced in building, and definite information should be obtained regarding the condition of each building, the feasibility of moving it to a new position on the lot, and the adequacy of the plant for use under present conditions. From this information a builder can readily provide estimates covering the cost of additions, alterations, and repairs. If a new all-steel, 22-foot plate-height fireproof ginning building is to replace a wooden building, a preliminary estimate of $2 per square foot of floor area may be safely used.

Cost of equipment and machinery may be most satisfactorily obtained directly from the manufacturers, because all items entering into the purchase, shipment, and erection are available.

ELEMENTS OF MODERN GINS

A modern cotton-gin plant is fireproof, conveniently arranged inside and outside, and properly lighted and ventilated, either artificially or naturally. It has cleaning or extracting equipment suited to the needs of the community, and the gin stands are equipped with huller fronts for further cleaning of the cotton. Provision is made for artifically drying green, damp, or wet cotton. The saw shafts of the gin stands are preferably directly connected for driving, and there is a minimum of shafting and belting. Bearings are of the antifriction type rather than of the old babbitt design. Cotton piping and fans are of a size that contribute to economy in power consumption.

Seed is elevated for disposal by sturdy and efficient elevators instead of by wooden bucket elevators that have given much trouble because of the slipping of the vertical driving belt and the misaligning of the elevator due to building shifts. Seed is more economically moved by a conveyor than by a blowing system. Such conveyors should be operated in steel troughs equipped with steel covers rather than in wood troughs having wooden covers and wooden cover strips. Various means have been devised for keeping seed pure.

Power-transmitting equipment for screw conveyors now includes high-speed countershafts, antifriction bearings, high-speed silent chains and roller chains, and gear reducers instead of the old-style heavy, long line shafts, babbitted bearings, belt drives, rope drives, gears, and countershafts that were formerly operated at low speeds with no protection. Seed scales are becoming standard equipment for accurately weighing seed purchased from the farmer, and a modern gin has a convenient waterproof hopper that drops the seed into the farmer's wagon.

Mechanical means for disposing of foreign matter at some distance from the plant are desirable. Modern gins also have adequate facilities for storage of bales where they will be protected against weather and fire. Shelter sheds protect wagonloads of cotton against rain. A seed-cotton storage house is arranged to provide for economically unloading seed cotton from wagons for storage and for transferring it from storage to the gin.

ARRANGEMENT OF BUILDINGS AND GROUNDS

Among the factors to consider in deciding upon the best arrangement of the ginning buildings are the shape and size of the lot, the location of entrances and exits with respect to the public highways, the position of railroad tracks, and the method of handling wagon and truck traffic through the entrances and exits of the lot.

Figure 1 shows three good lot arrangements. The shape and size of the lot and the location of the gin with reference to roads and railroads may prevent the adoption of ideal arrangements, so no hard and fast rule can be laid down.

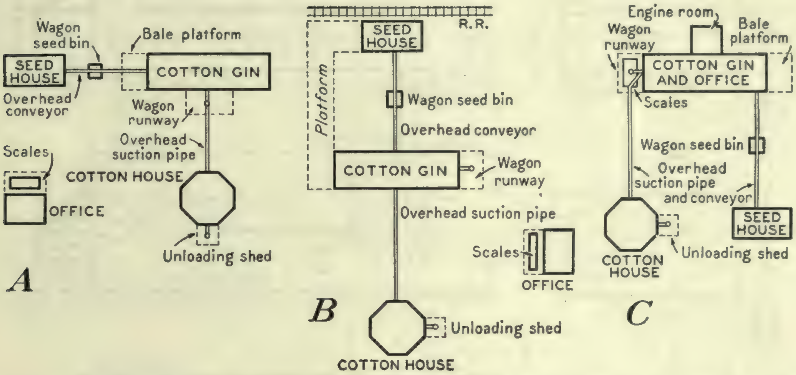
Wagon seed bin
Bale platform
SEED HOUSE
COTTON GIN
Overhead conveyor
Wagon runway
Overhead suction pipe
Scales
COTTON HOUSE
OFFICE
Unloading shed
A
R.R.
SEED HOUSE
Platform
Wagon seed bin
Overhead conveyor
COTTON GIN
Wagon runway
Overhead suction pipe
Scales
OFFICE
B
Unloading shed
COTTON HOUSE
Engine room
Wagon runway
Bale platform
COTTON GIN AND OFFICE
Scales
Wagon seed bin
Overhead suction pipe and conveyor
SEED HOUSE
COTTON HOUSE
Unloading shed
C

FIGURE 1.—Arrangements of buildings of modern cotton gins: *A*, Operations from a special office on the grounds; *B*, office may be either separate or within the ginning building; *C*, third most popular arrangement for position of buildings.

No shelter sheds or other accessories have been indicated in the foregoing lay-outs for positions of buildings because the number and location of such accessories are largely dependent upon local conditions and practices. Different communities handle cotton in different ways, although the simplest method of weighing in general use is that in which the wagon scale is either in front of the office or beneath the suction pipe of the gin.

BUILDING CONSTRUCTION FOR GINS

Fireproof gin buildings are highly desirable, and if they cannot be of masonry or all metal, they should be of heavy, mill-type timber coated with fire-resistant materials. Good illumination and ample headroom are necessary. Figure 2 shows cross sections and plans of gin buildings with desirable dimensions. Double-battery outfits require widths of 40 feet or more, and all installations should have at least 16 feet between the floor and roof plate. The length of the building should be coordinated with the number of gin stands. Straight-line roofs are desirable, but offset ones are frequently employed in one-and-one-half-story gins to obtain ample headroom over the press platform.

In new all-steel buildings, full-length overhung wagon sheds and runways are favored because there are no posts to be damaged by careless driving or accident. This necessitates strengthening certain parts of the building for ample support. Such construction is particularly desirable on city lots and other restricted spaces if the additional cost is not too great.

The roofs of modern gin buildings may be flat, pitched, or curved, but, above all, they should be fireproof and readily accessible for cleaning and repair. Many types of trusses are in use, the best forms being of structural steel or heavy timber framed so that block and tackle loads may be supported from the lower chords. By selecting the roof trusses with this in mind, the installation, removal, and rearrangement of ginning machinery is made safer and simpler.

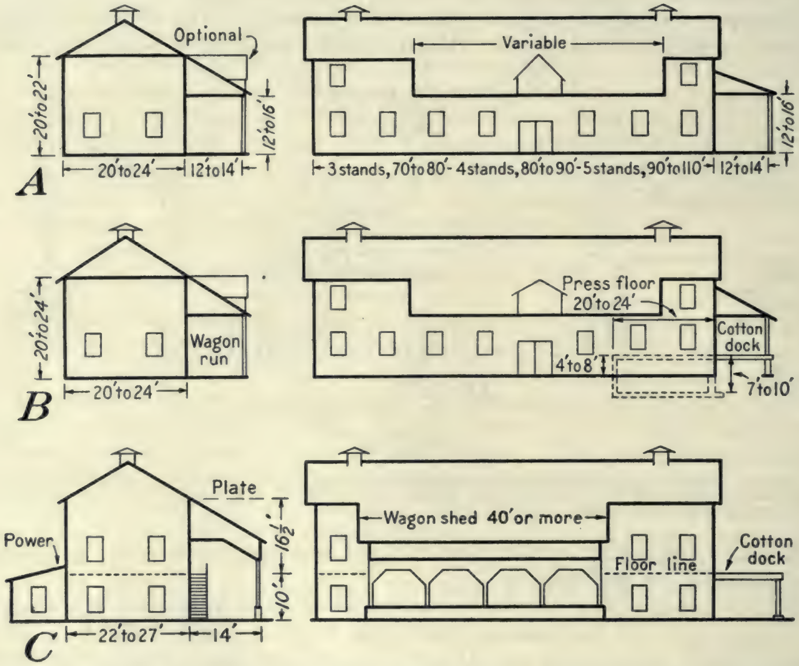
Optional
20' to 22'
20' to 24'
12' to 14'
12' to 16'
A
Variable
3 stands, 70' to 80' - 4 stands, 80' to 90' - 5 stands, 90' to 110'
12' to 14'
12' to 16'
20' to 24'
Wagon run
20' to 24'
B
Press floor 20' to 24'
Cotton dock
4' to 8'
7' to 10'
Plate
Power
16½'
10'
22' to 27'
14'
C
Wagon shed 40' or more
Floor line
Cotton dock

FIGURE 2.—Dimensions of modern gin buildings for single outfits: *A*, One-story gin; B, one-and-one-half story gin; *C*, two-story gin.

If a gin building has more than one story or platform in connection with a ground-level floor, inclines or ramps are better than steps as bales may be moved on them easily and heavy machinery may be safely moved with rollers and block and tackle.

Buildings should be made ratproof wherever possible. Farmers' Bulletin 1638, Rat-proofing Buildings and Premises, gives information on protection against rodents. Concrete floors, parapets, and guards make this a relatively simple matter in modern all-steel construction.

Single-story gin buildings with concrete floors have been gaining in favor because they are more permanent and permit more rigid installation of equipment. For such buildings, the bale presses are either down-packing or up-packing and of the single-story type. Some form of crane, incline, or lift is consequently needed to raise the bales from the ground level to that of the railroad platform or truck bed unless the floor level is unusually high. The use of factory-built steel doors and window sash provides protection against unwarranted entry.

In some cases a one-and-one-half-story gin building is preferred. In it machinery may be kept on the ground level and yet permit the use of a standard two-story press in conjunction with an elevated platform for cotton dock and press deck. It is desirable to have the platform of reinforced concrete and to have beneath it a half cellar with full headroom for pump, workbench, storage spaces, and miscellaneous machinery.

Very few new two-story gin buildings are now being built except on cotton farms to house relatively small outfits. These buildings are usually framed with wood and sheathed with galvanized iron. The principal advantages of a two-story gin building are that the ground floor may be used for seed sacking directly beneath the gin stands, and the main line shaft may be placed on concrete pedestals so that belt drives may be carried upward through the ginning floor without occupying too much space or being hazardous to workers. However, improved ginning machinery operates best in a single-story or one- and-one-half-story building.

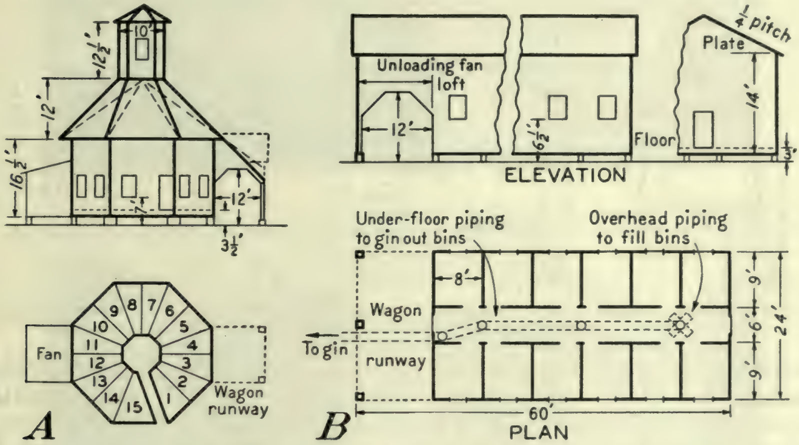

FIGURE 3.—Diagrams and principal dimensions of houses for the storage of seed cotton: *A*, Octagonal; *B*, rectangular.

It is seldom that the gin building can be constructed to contain the seed cotton and seed storage; and, from the viewpoint of fire underwriters, there are many reasons why the gin building should be separate from other buildings on the premises. In many States, a minimum distance of 50 feet between buildings is required by the insurance authorities if lowest rates are to be obtained.

Figure 3 gives diagrams and dimensions for seed-cotton storage houses that are much in use throughout the Cotton Belt. The octagonal cotton house is compact and may be filled either by the suction dropper or Rembert type of cotton fan. In some instances the suction fan is within the gin building proper, and the pipe to the cotton house may be used for both suction and cotton-handling purposes.

That is to say, the piping is used for suction when the cotton house is being filled and for transferring seed cotton to the gin stands when the house is being emptied.

Rectangular cotton houses are preferred in some sections; and both belt and pneumatic systems are used for filling the bins. These houses are usually single-story, framed with wood, and sheathed with galvanized iron. The floors are preferably of wood because cement floors often collect moisture, which is detrimental to the cotton.

Storage houses for cottonseed may be of the types shown in figure 4, *A* and *B*. Those with battered or sloping side walls and ends are among the later developments. Combination, or two-story seed and seed-cotton houses are not so common as individual houses for each product but may be economically and ingeniously erected as indicated in figure 4, *C*.

COTTON DOCKS AND BALE STORAGE

The form and extent of cotton docks in a large measure depend upon the buildings and grounds. It is customary to have a sheltered dock at the end of the ginhouse with bale runway and bale platforms, either unsheltered or sheltered, shown in figure 5, *A* and *C*. The elevated skeleton platform shown at *B* is a unique method of handling cotton bales where shelter is not provided. The bale house, shown at *D*, affords complete protection in rainy weather.

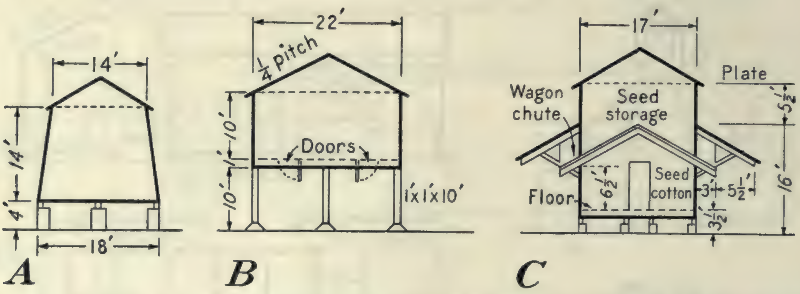

FIGURE 4.—Diagrams and principal dimensions of houses for storage of cottonseed: *A*, Ground-level seed-storage house; *B*, elevated drive under house; *C*, combined seed and seed-cotton storage.

Fire hazards to buildings and bales warrant fireproof construction and elimination of possibilities of conflagration being spread from burning bales or railroad equipment. It is good practice to have bale-storage facilities at sufficient distance from the gin house to prevent spreading of fire from bales to the gin proper.

CONDITIONERS

In most parts of the Cotton Belt a modernization of the ginning outfit must include the installation of conditioning or drying apparatus. Many types that employ the Government process are now on the market. The tower driers, which are described in Miscellaneous Publication 239, The Vertical Drier for Seed Cotton, may be located either on the ground level or over the distributor or overhead cleaner. Several improved methods of installation are shown in figure 6.

Among the other forms of driers on the market whose drying processes are similar to that developed by the United States Department of Agriculture are the unit extractor-feeder system of drying, multiple

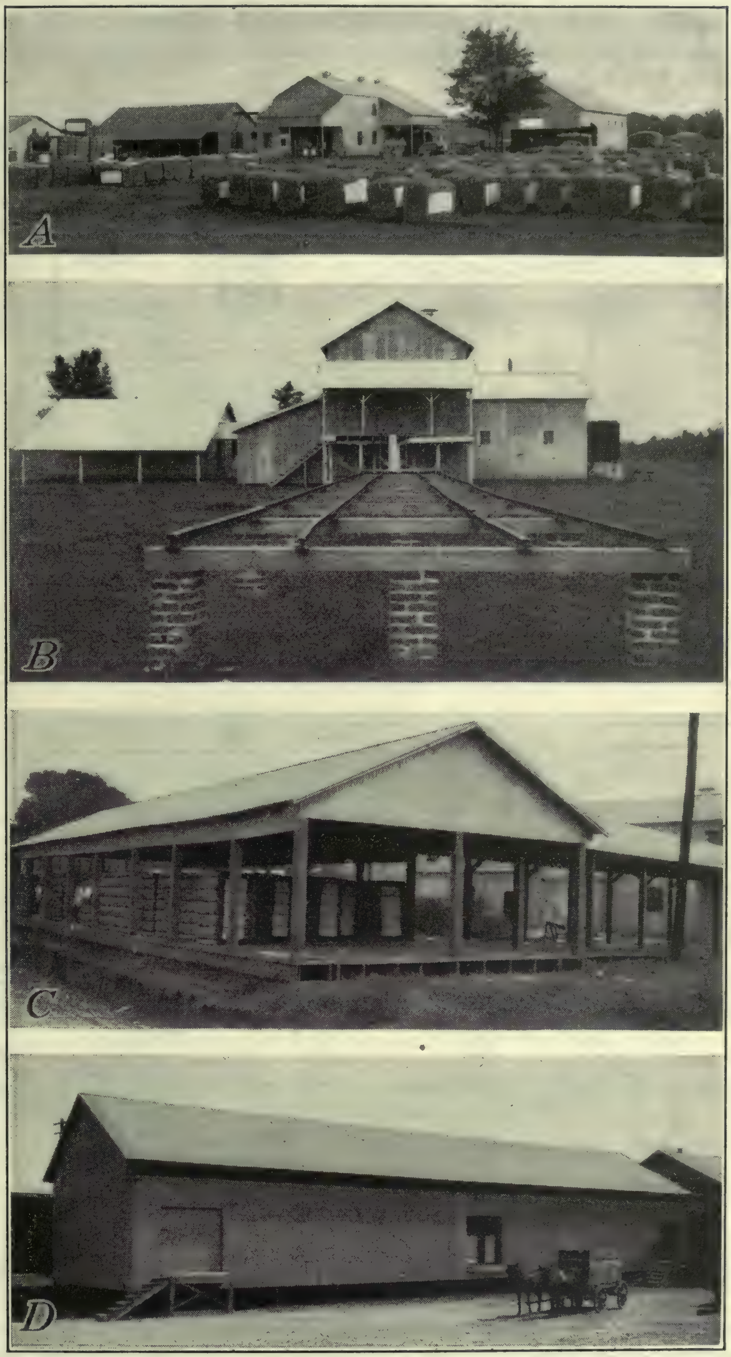

FIGURE 5.—Cotton dock and bale storage: *A*, Unsheltered on ground level; *B*, unsheltered, elevated; *C*, sheltered, open; *D*, sheltered, enclosed.

conveyor-distributor drier, ribbon conveyor-cleaner type of drier, overhead cleaner methods of drying, multiple-cylinder axial-flow air-line cleaner-drier and revolving-floor vertical-cylinder drier, which are shown in figure 7.

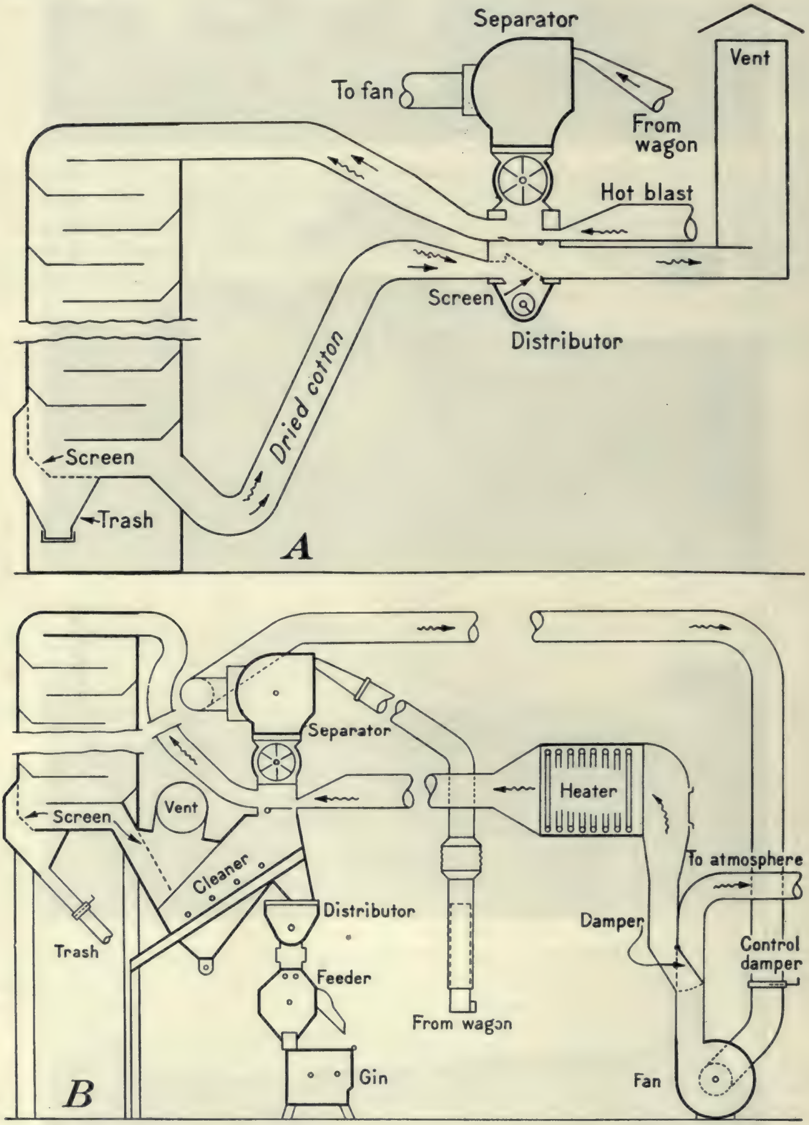
Separator
Vent
To fan
From wagon
Hot blast
Screen
Distributor
Dried cotton
Screen
Trash
A
Separator
Vent
Screen
Heater
To atmosphere
Cleaner
Distributor
Damper
Control damper
Trash
Feeder
From wagon
Gin
Fan
B

FIGURE 6.—Diagram of newer installations of the vertical seed-cotton driers: *A*, Full-length, 17-floor, ground-level pressure system; *B*, overhead, 9-floor drier combined with overhead cleaner, using single-fan method of feeding.

As many of the smaller ginning establishments cannot afford most of the driers described, the Department has developed a drying system that has a low installation cost and is inexpensive to operate. Diagrams of this system are shown in figure 8 for both mechanical and pneumatic systems. The installation costs may be held between $500 and $700 when the gin is already equipped with an air-line cleaner.

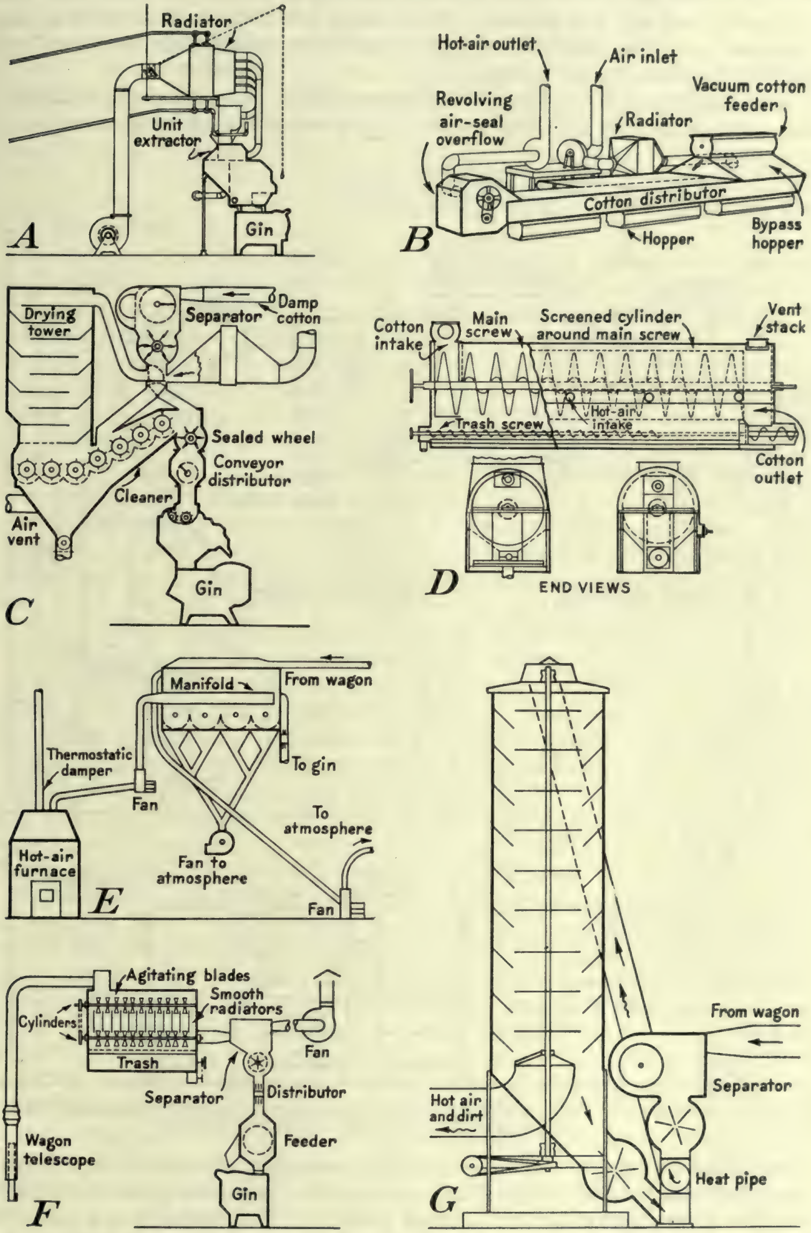
Radiator
Unit extractor
Gin
A
Hot-air outlet
Air inlet
Vacuum cotton feeder
Revolving air-seal overflow
Radiator
Cotton distributor
Hopper
Bypass hopper
B
Drying tower
Separator
Damp cotton
Sealed wheel
Conveyor distributor
Cleaner
Air vent
Gin
C
Cotton intake
Main screw
Screened cylinder around main screw
Vent stack
Hot-air intake
Trash screw
Cotton outlet
D
END VIEWS
Manifold
From wagon
To gin
Thermostatic damper
Fan
To atmosphere
Hot-air furnace
Fan to atmosphere
Fan
E
Agitating blades
Smooth radiators
Cylinders
Fan
Trash
Separator
Distributor
Feeder
Wagon telescope
Gin
F
From wagon
Separator
Hot air and dirt
Heat pipe
G

FIGURE 7.—Various forms of commercial driers on the market: *A*, unit extractor-feeder system of drying; *B*, multiple conveyor-distributor drier; *C*, overhead vertical drier and cleaner; *D*, ribbon-conveyor cleaner drier; *E*, paddle-wheel-drum cleaner drier; *F*, multiple-cylinder axial-flow air-line drier; and *G*, revolving-floor, vertical-cylinder drier.

The system involves the addition of heater coils and inlet adapter to cleaner, by means of which a hot-air suction combines with the seed-cotton suction from the wagons so as to convert the cleaner into a drying chamber. Since one cotton fan provides the necessary suction from both wagon and heater, a fan having a capacity of 3,600 to 5,400 cubic feet of air per minute, depending on the number of stands, is necessary. This installation is especially applicable to small gins having pneumatic elevators.

The source of heat for the different driers may be either boilers or arrangements for utilizing waste heat from a Diesel or gas engine exhaust and radiator. It is generally desirable to install any form of drier so that its use will not interfere with the ginning service and will require a minimum of additional power. The installation shown in figure 6, *B* permits the vertical drier to be used with or without heat very beneficially and requires no additional power to operate. Some of the other forms of driers shown are, by various methods of installation, able to achieve these same effects.

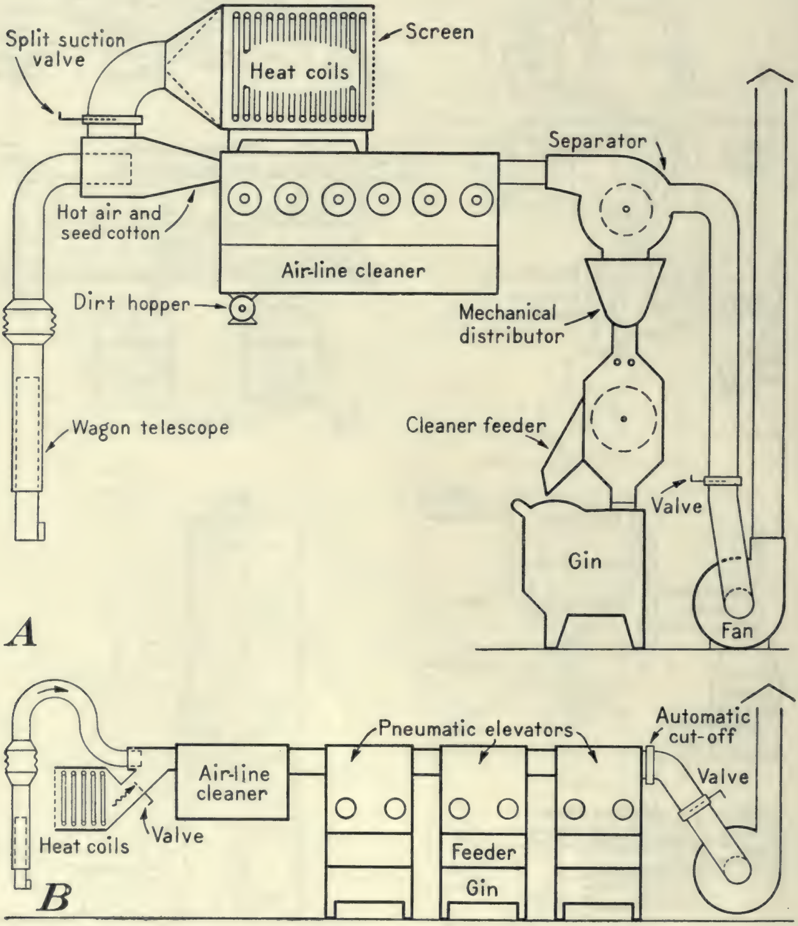
Split suction valve
Screen
Heat coils
Separator
Hot air and seed cotton
Air-line cleaner
Dirt hopper
Mechanical distributor
Wagon telescope
Cleaner feeder
Valve
Gin
Fan
A
Pneumatic elevators
Automatic cut-off
Valve
Air-line cleaner
Heat coils
Valve
Feeder
Gin
B

FIGURE 8.—Diagrams of air-line drier using split suction and one fan: *A*, Applied to mechanical distributing system; *B*, applied to pneumatic distributing system.

CLEANERS AND EXTRACTORS

In modernizing cotton-ginning establishments, the methods of harvesting employed in the locality of the gin, the kinds of cotton, and the usual weather conditions should all be considered in conjunction with the kind of distributing system for the gins, because these factors determine the extent to which conditioners, cleaners, and extractors must be employed. More complete discussions of these subjects are to be found in Farmers' Bulletin 1748, Ginning Cotton, and Technical Bulletin 508, The Effect of Artificially Drying Seed Cotton before Ginning on Certain Quality Elements of the Lint and Seed and on the Operation of the Gin Stand.

Two forms of distributing or feeding systems are common to ginning establishments—mechanical and pneumatic. Most saw-ginning establishments in the United States utilize one or the other, and cleaning or other auxiliary equipment must be chosen accordingly.

In the mechanical system, the seed cotton may be drawn continuously from the wagon, overflow floor, or cotton house, and any surplus seed cotton is discharged at the overflow, from which it may be again returned to the handling system. This system is therefore suitable for use with many combinations of conditioning, cleaning, and extracting machinery and is now the most popular system, but it requires somewhat more power than the pneumatic system. The pneumatic system is not generally used in modern gins because it is intermittent in its suction from the wagons and cannot unload them faster than the gin stands can handle the cotton. Furthermore, it has no overflow and is not readily adaptable to the use of other than air-line cleaners, nor can it handle rough cotton effectively.

It is customary to assume that a cleaner is of the out-of-air or gravity type unless it is specifically referred to as "air line." Air-line cleaners are principally employed in pneumatic systems, but they may be used advantageously in mechanical systems to simplify the equipment or to conserve space by being placed over the wagon runway. They may be obtained in a variety of forms such as the axial-flow, cross-drum, or serpentine types. Cylinders for cross-drum types of cleaners may be equipped with spikes, spider arms, or paddles.

In general, air-line cleaners permit only a horizontal flow of the seed cotton from inlet to the outlet of the machine, but inclined cleaners are common in mechanical-distributing systems where there is little headroom. Modern forms of inclined cleaner-separator installations are shown in figure 9. The separator is mounted at the lower end of the cleaner, as illustrated at *A*, in gins where headroom is limited. Frequently the separator is placed at the upper end with a bypass so that the cotton may be discharged either to the cleaner or directly into the distributor, as shown at *B*.

Extracting units are more effective in removing burs, sticks, and other foreign matter from roughly harvested cotton than cleaners. Large extracting machines may be used in overhead positions as master extractors to serve the entire ginning battery, or small machines may be used as unit extractor-feeders to supply individual gin stands and to replace older forms of cleaning feeders.

General trends in the installation of cleaners and extractors are toward simplicity and compactness with a view to having a minimum

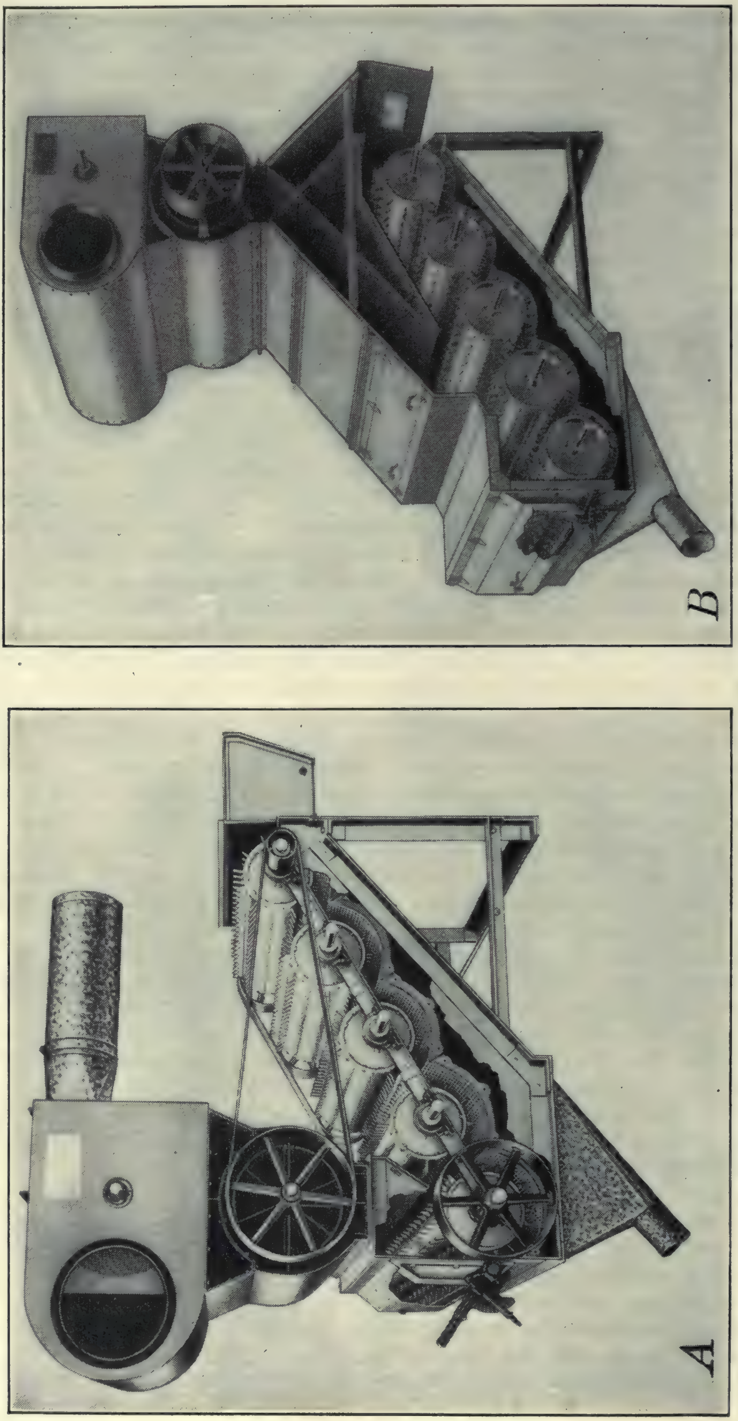

FIGURE 9.—Inclined-cleaner installations: *A*, With separator in low position; *B*, with separator and by-pass elevated.

amount of overhead cleaning apparatus. For this reason unit extractor-cleaner-feeders are frequently substituted for overhead cleaners, master extractors, and cleaning feeders.

A modern combination of overhead cleaning and extracting machinery for use in districts where cotton is usually roughly harvested s shown in figure 10.

In the Southeastern States, unit extractor-feeders placed above existing plain gin stands are a simple and economical step toward modernization. Where new gin stands are purchased, it is more desirable to obtain huller stands and combine them with unit extractors as shown in figure 11. This arrangement is very popular in the central cotton States and in many sections of the western part of the Cotton Belt.

If possible selection of cleaning equipment should be considered at the same time as the selection of the drying equipment because often, with proper planning, combinations of cleaning and drying equipment can be installed together much cheaper than separately. The use of drying equipment reduces the need of cleaning equipment.

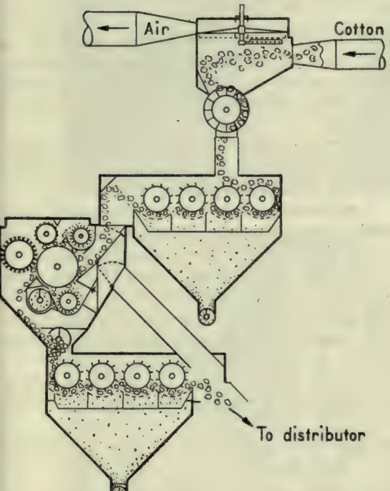

FIGURE 10.—Diagram of typical overhead cleaning and extracting combinations for districts where cotton is roughly harvested.

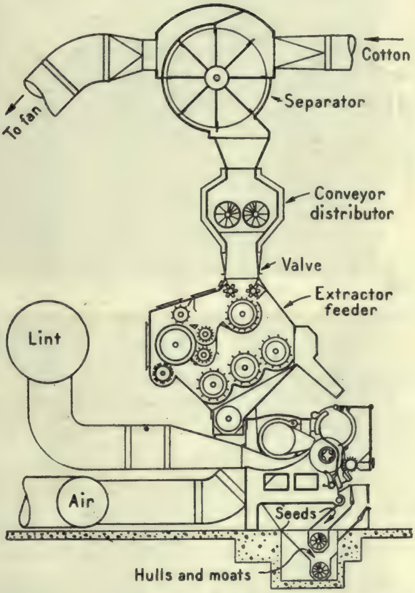

FIGURE 11.– Diagram of a huller stand equipped with a unit extractor-cleaner feeder.

GIN STANDS

Plain gin stands are rapidly being superseded by double-ribbed huller gins whose fronts remove appreciable quantities of leaves, stems, and minor items of foreign matter even when elaborate cleaning and extracting processes have preceded them. The picker rollers on huller gins of the latest models are equipped with lever shifting devices so that the position of the roller may be adjusted to the immediate condition of roughness in the seed cotton. Beginning about 1930, gin stands appeared in all-steel construction that are virtually rodentproof and afford a superior protection to the cylinders and brushes or nozzles. Many manufacturers now offer huller fronts as substitutes for plain fronts on certain models of gins at a cost less than $100 each, but attempts to provide huller fronts for older wooden gins are less satisfactory and may involve an expenditure up to $225 per gin stand. Sections of plain and huller types of gin stands are shown in figure 12.

HANDLING SEED FROM STANDS

Seed and trash may be handled readily by various means such as gravity, belts, screw conveyors, and pneumatic piping. There are several practical methods for handling seed so as to keep it pure. The belt and blowpipe types of seed conveying are self-cleaning, but screw conveyors must be hand-cleaned between the ginning of different varieties. The use of belt or blowpipe conveyors are therefore desirable where an appreciable quantity of seed is to be saved for planting. The following methods are among those now in use:

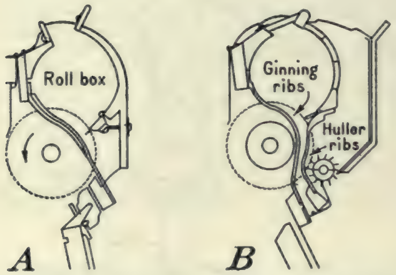

FIGURE 12.—Diagram of gins: *A*, Plain; *B*, double-ribbed huller.

1. A horizontal flat seed belt in a smooth trough below the stands, delivering either to an inclined belt or to a seed-blowing pipe through a vacuum wheel seed feeder.
2. A horizontal skeleton drag belt operating in practically the same way as the flat belt described above.
3. A reversible horizontal flat seed belt beneath the stands, operating in one direction to deliver gin-run seed, and in the other to deliver pure seed, each discharging into bins or sackers by various means.
4. Two individual conveyors beneath the stands, gin-run seed being handled in the rear system and pure seed in the front one—each system having its own lifts and deliveries.
5. Gravity chutes with hinged covers in front or below each stand, diverting pure seed by gravity into funnels and sacks below, while a standard screw conveyor is generally used on gin-run seed.
6. Gravity chutes similar to those described above but delivering pure seed into a blowpipe by means of rotating vacuum wheel seed feeders.

Improved seed conveyors are shown in figure 13.

Where vertical lifts are employed, the modern screw elevators are proving much more efficient and sturdy than the wooden-bucket elevators, whose troubles with slipping belt and faulty alignment are well-known. Seed and trash may be readily handled by belts or conveyors. In some instances these may discharge into air piping, but the operation of conveying trash and seed entirely by air is more expensive than other methods.

FANS AND AIR PIPING

The problems of piping and fans will be more readily understood by keeping in mind that the flow of air in a pipe in cotton gins is similar to the flow of water in a pipe. Quantities are measured in cubic feet per minute for the air and in gallons per minute for the water. Static

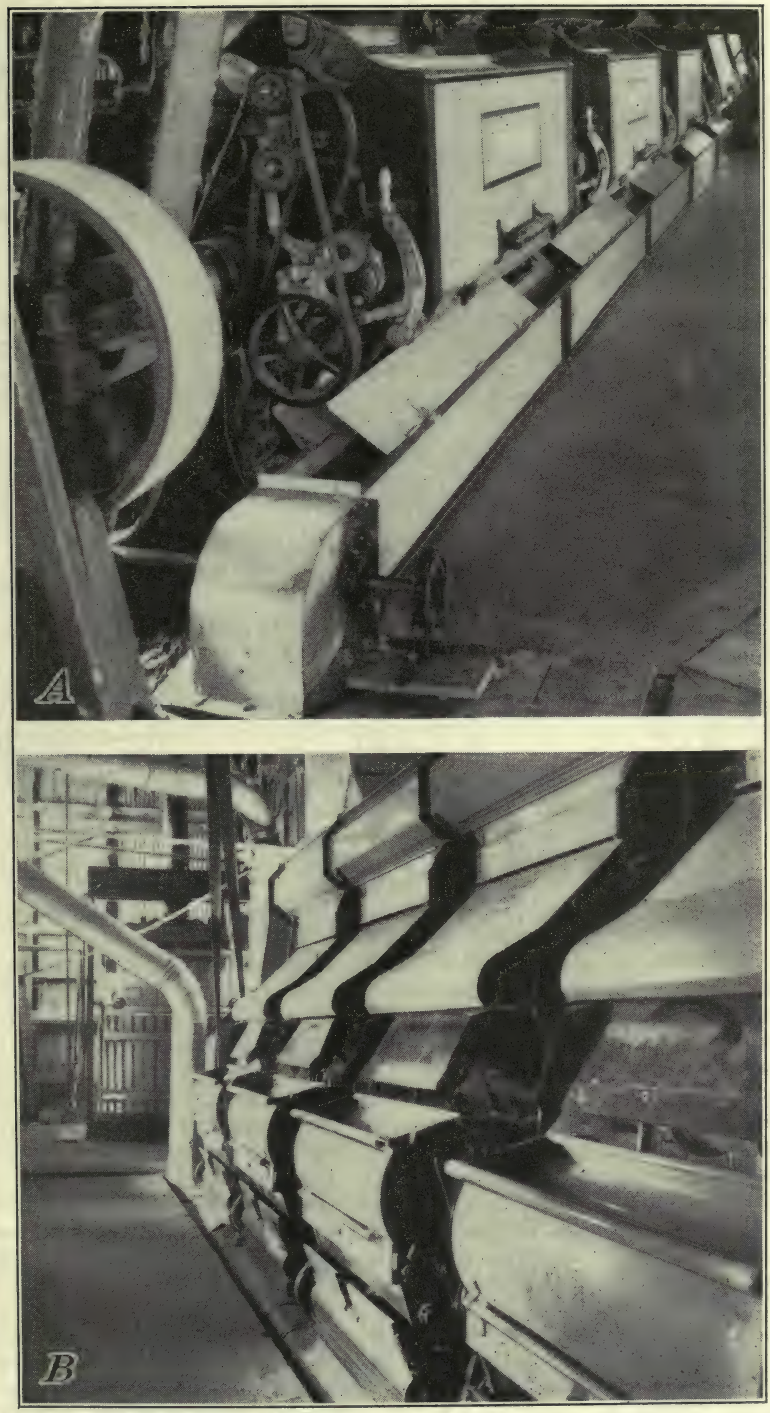

FIGURE 13.—Improved methods of keeping seed pure at cotton gins: *A*, Seed belt; and *B*, blowpipe.

pressures in the air piping correspond to pounds-per-square-inch pressures in water pipes. Pipe sizes are selected in both to obtain the desired quantities under resistance conditions that are suitable for the fans or pumps, and friction loss in the air piping is similar to loss of head in water pipes.

Many ginners find it difficult to obtain full effectiveness from their fans and cotton piping because the fan speeds and sizes of pipe are not always correct. Waste of power and added operating expense result from both excessive fan speeds and incorrect piping.

FANS

Fans are used in cotton gins chiefly (1) to convey seed cotton from the wagon or cotton house to the ginning machinery, (2) to operate cotton conditioners or driers, (3) to supply necessary volumes of air to the doffing nozzles of air-blast gins, and (4) to convey seed, hulls, and trash.

The selection of a fan should be governed by the required air volume and system pressure as well as by the general purpose for which it is to be used. Although seed cotton or cottonseed should not be permitted to pass into the scrolls or wheels of standard fans, the use of Rembert type fans is permissible.

Two kinds of fan wheels are shown in figure 14, of which forms *A* and *B* are standard and *C* is the Rembert wheel. With equal diameters and number of revolutions per minute each of these wheels gives different volume and pressure, necessitating selection from individual-performance tables, which are usually obtainable from the manufacturers. In selecting a fan, choice should be made by specific reference to wheel diameter, kind of wheel, number of blades, and kind of casing (such as cast or steel plate), rather than employing vague terms such as "No. 35" or "35-inch" because such identifications are not used by all fan makers. In fact, the No. 15 fan of one company may correspond to the so-called 35-inch fan of another. It is a wise precaution to specify a fan wheel with a diameter at least twice as large as that of the main pipe leading to its inlet, because this choice will tend to fall within the desirable range of fan sizes that do not require excessive speed in either standard or Rembert types.

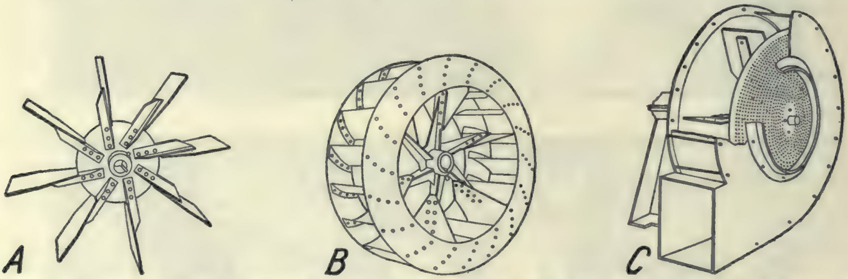

FIGURE 14.—Representative types of gin-fan wheels: *A*, Plain 8-blade wheel; *B*, shrouded 18-blade wheel; *C*, Rembert-type wheel, in the casing.

Dimensions of standard wheels in a series of any particular make are increased either in diameter or in width of wheel to produce increased capacities, as shown in table 1, which gives the range of volumes, pressures, and speeds for different diameters of standard wheels commonly used in conveying seed cotton.

TABLE 1.—*Approximate wheel diameters, advisable capacities, and safe speed ranges for standard types of cotton suction fans operating between 3 inches and 10 inches static pressure* [1]

Approximate diameter of wheel (inches)	6-blade shrouded wheel		18-blade shrouded wheel	
	Advisable capacity range [2]	Speed range	Advisable capacity range [2]	Speed range
	Cubic feet per minute	*Revolutions per minute*	*Cubic feet per minute*	*Revolutions per minute*
20	1, 500–2, 599	1, 260–2, 305	2, 300–4, 000	1, 300–2, 800
23	2, 600–3, 599	1, 160–2, 000	3, 200–5, 400	1, 150–2, 400
26	3, 600–5, 099	1, 060–1, 830	4, 200–6, 900	1, 000–2, 100
30	5, 600–8, 699	960–1, 650	5, 200–8, 800	900–1, 900

[1] In inches of water measured on U-tube gage.
[2] These ranges have been indicated by fan manufacturers.

NOTE.—This table is computed from performance tables of several makes of fans.

Rembert-type fans are frequently employed in cotton conditioners as well as at cotton houses for unloading seed cotton from wagons to storage bins, but it has only recently become a practice to apply such fans to ginning systems in order to replace separators and standard fans. In many cases of successful operation with Rembert-type fans, direct connections with electric motors are used. Volume and pressure characteristics of Rembert-type fans differ so much for different makes that it is desirable to consult the manufacturers for specific performance information. As a rule of thumb, however, it may be said that a Rembert fan with any given diameter wheel seldom has a capacity equal to a one-size-smaller standard fan with a wheel running at the same speed.

Housings for fans should be of the universal kind so that the fan may be used either right or left hand and be adjustable to at least eight positions. For continuous economical service, ball or roller bearings should be used on fans.

TABLE 2.—*Performance comparisons of 6-blade and 18-blade fans for air volumes at 5 inches of water, static pressure*

6-blade fan			18-blade fan		
Revolutions per minute	Volume	Brake horsepower	Revolutions per minute	Volume	Brake horsepower
1, 273	2, 500	3. 6	1, 042	2, 500	3. 6
1, 352	3, 350	5. 0	1, 130	3, 350	4. 7
1, 433	4, 160	6. 5	1, 200	4, 160	5. 9
1, 511	4, 920	8. 3	1, 271	4, 920	7. 2
1, 591	5, 630	10. 0	1, 341	5, 630	8. 6

When a fan that is worn out or is using too much power is to be replaced, an efficient type should be selected. Suitable fans may be intelligently selected from the performance tables that most manufacturers will supply upon request. These tables usually show a wide range in design and performance. High-efficiency fans of slow speed have greater diameters and narrower wheels than standard gin fans. The greater first cost of such a fan is offset by lower power consumption. Table 2 shows the capacity and power requirements of 6- and 18-blade fans operating at various speeds. The figures are averages of several makes of fans.

HANDLING SEED COTTON BY AIR PIPING

From 800 to 1,000 cubic feet of air per minute is usually required at the wagon telescope to supply seed cotton to each gin stand, depending upon the type of system and the length of suction piping. If a cotton-house suction pipe is included, a modernized piping layout may be designed to give the same friction loss and constant volume from the cotton house as from the wagon telescope, affording a satisfactory conveying velocity in the largest pipe. In such a system, the wagon-telescope suction velocity may be maintained from 5,000 to 6,000 linear feet per minute so that smaller piping on this short run will give equal resistance to the longer line of larger piping to the cotton house. The selection of fan size and speed is thus simplified and more economical operation assured.

Table 3 shows typical data for balanced systems having different diameters of the various suctions but giving approximately equal resistances or static pressures for both wagon suction and suction from the cotton house. Improved types of separators having less leakage than allowed for in table 3 will reduce the speed and power requirements correspondingly.

TABLE 3.—*Sizes of cotton-suction piping proportioned to give economical fan operation and approximately equalized resistance* [1]

Gin stands (number)	Volume of air	Approximate diameter of wheel in the 18-blade fan	Suction piping						Fan speed and horsepower			
			System A[2]		System B[3]				System A[2]		System B[3]	
					To wagon		To storage					
			Diameter	Velocity	Diameter	Velocity	Diameter	Velocity	Fan[4]	Horsepower	Fan[4]	Horsepower
	Cubic feet per minute	*Inches*	*Inches*	*Feet per minute*	*Inches*	*Feet per minute*	*Inches*	*Feet per minute*	*Revolutions per minute*		*Revolutions per minute*	
3	3,000	23	10	5,500	10	5,500	12	3,800	1,500	10	1,600	11
4	4,000	26	11	6,060	11	6,060	13	4,350	1,450	14	1,500	15
5	5,000	30	12	6,370	12	6,370	14	4,700	1,400	13	1,440	20

[1] For diagram of piping, see fig. 15.

[2] With equivalent length (including elbows) of 50 feet from separator to nose of wagon telescope, and with no cotton house piping.

[3] With equivalent length (including valves and elbows) of 150 feet from separator to cotton-house suction point, and with wagon suction piping as for system A.

[4] Averaged from performance tables of several makes of 18-blade shrouded fans but not guaranteed.

Diagram plans of piping for systems A and B given in table 3 are shown in figure 15. In these systems, the wagon and overflow telescopes should be the same size, but where cotton-house suction and overflow employ the same piping in part, the size of the cotton-house line should be continued to the separator, with reduced size at the secondary valve for the overflow connection. Valves in all seed-cotton suction lines should be placed in a vertical position to prevent unequal distribution of seed cotton into the separator, and the piping from the separator to the fan should be preferably three-eighths to one-half of the fan-wheel diameter, without reduction into the fan inlet. The piping from the separator and the fan should in all cases be equal to or greater than that for the seed-cotton suction.

In a pneumatic-elevator system (having no mechanical separator) the above rules will still apply, but if no ginned seed is to be blown by the fan discharge, a cut-off valve of the butterfly or stove-damper type will save power, since the fan is not loaded when the gins are idling.

A ginner may frequently encounter conditions in which the lengths of piping are different from those given in footnote to table 2. Under such circumstances, the use of the cotton-piping chart (fig. 16) will be of assistance in working out the friction losses in order to balance or give equal losses to the cotton-house and wagon lines.

By keeping in mind the similarity between air and water piping and by observing rule 7 (p. 21), the use of the chart will be found quite simple. For example: A certain three-stand outfit is to be installed with a 10-inch wagon telescope and suction line the equivalent length of which is 50 feet between the nose of the telescope and the valve at the separator inlet, and it is desired to lay out a system similar to figure 15, *B*, in which the cotton-house suction piping will have 80 feet of straight pipe and five 90° elbows.

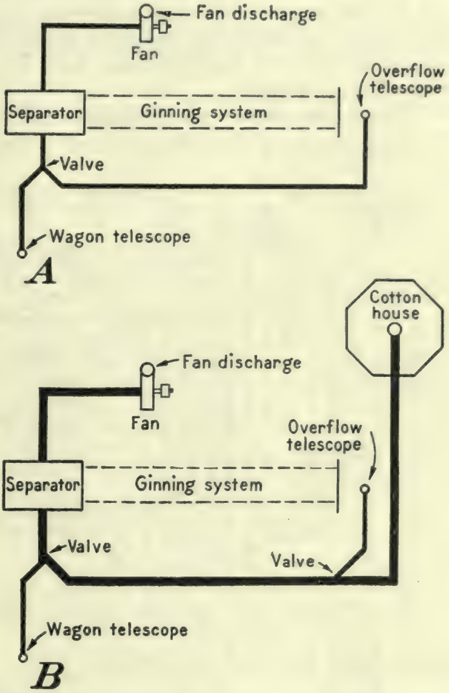

FIGURE 15.—Diagrams of typical cotton gin piping systems: *A*, With wagon suction and overflow only; *B*, with both wagon and overflow suctions and cotton-house piping.

The following is an example of the calculations required:

Wagon suction line

1. From figure 16, the friction loss per hundred feet of 10-inch piping handling 3,000 cubic feet of air per minute is 4. 80
Since the equivalent length of the wagon suction is 50 feet its loss is 2. 40

Cotton-house suction line

2. From 1, the friction loss per hundred feet of the cotton-house line must be 2. 40
3. Equiv. length, 100 ft. units, of this cotton-house line is—
Straight pipe 80
Five elbows at 10 feet 50

Total 1. 30
4. The loss per 100 feet must therefore be 2.40 divided by 1.30, or 1. 85
5. From chart (fig. 16) a 12-inch pipe will deliver 3,000 cubic feet per minute with this friction loss.

There must always be an adequate velocity in piping to provide ample suction. In the foregoing example, the dotted line for 1.85 inches of water resistance per hundred feet of piping intersects the 12-inch diameter pipe line between the 3,500 and 4,000 feet per minute diagonal lines of velocity. This is not an extremely strong suction, but it is considered sufficient to warrant the use of the 12-inch pipe. If, however, certain cases are encountered where the velocity within the pipe is indicated as less than 3,500 feet per minute, the next-smallest size of piping that will give at least a 3,500-foot velocity should be chosen.

Manufacturers' performance tables should be consulted in making the selection of the proper size of fan, but it will first be necessary to estimate the static pressure, or friction loss, against which the fan is to operate and also the total volume of air to be handled before reference can be made to the correct tables. This static pressure is the sum of the suction-piping resistance to the separator, plus friction losses in the separator and piping therefrom to the fan inlet, plus any losses that may exist on the discharge piping of the fan. Separators may introduce as much as 4 inches of water-friction loss with a leakage of from 1,000 to 1,200 cubic feet per minute and the piping losses from separator to the fan inlet plus those from the fan discharge to the atmosphere may comprise another 3 inches, making the total friction loss in the example about 10 inches. In such a case the manufacturers' tables on 10 inches static pressure and 4,000 cubic feet per minute capacity should therefore be taken as the basis for fan size and performance.

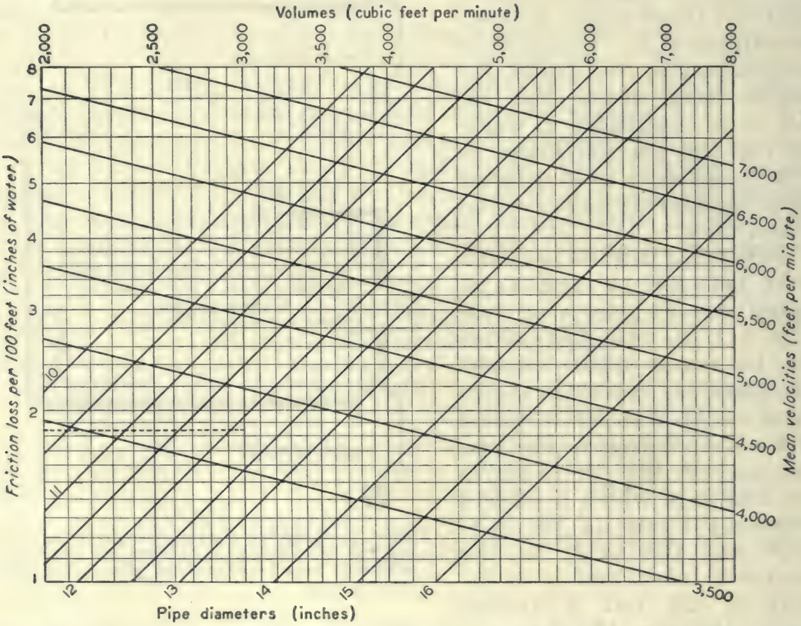

FIGURE 16.—Cotton-piping chart, giving friction losses in inches of water per hundred feet of piping for different diameters, volumes, and velocities.

In case a fan is to be installed in an existing piping system, it is advisable to obtain actual engineering observations before removing the old fan, as this will provide a simple and dependable basis for determining the required speed of the new fan.

GENERAL RULES FOR PIPING

Certain simple rules for successful installations of seed-cotton handling systems have been established after many years of experience. Some of these rules are:

1. Make the piping as simple and direct as possible by eliminating all unnecessary elbows and valves.
2. Good suction in a seed-cotton pipe requires a minimum velocity per minute of at least 3,500 feet, but velocities of 4,000 to 7,000 feet per minute are better; 4,500 feet per minute velocity is considered to be very good.
3. For blowing seed, the velocity in the pipe should be at least a mile a minute, and hence the pipe diameter should be kept between 10 and 13 inches.
4. All piping for cottonseed and seed cotton must run level or slope upward in the direction of flow. Downward slopes cause chokages.
5. Wagon-suction piping and the overflow piping should be reasonably small in order to obtain the highest velocity with the least air volume. Consequently, a 10-inch suction is best for three stands, an 11-inch suction for four stands, and a 12-inch suction for five stands. Larger suction pipes will decrease the velocity and increase the power cost.

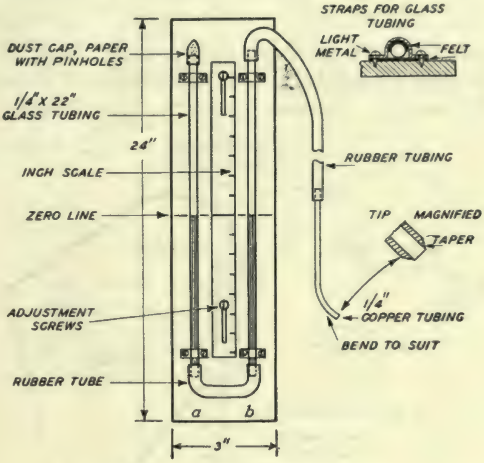

FIGURE 17.—Portable air-blast gage.

6. For cotton houses, a Rembert-type fan is simple and economical for handling the seed cotton, but a standard fan and separator with correct piping can be employed satisfactorily when used with a belt or screw conveyor in horizontal houses and with a revolving chute in octagonal houses. Fire hazards must be avoided in both systems.
7. The friction loss in cotton piping from the cotton house to the gin should approximately equal that in the wagon-suction line, so that a constant speed of the cotton fan can be selected that will be equally efficient for both.

AIR-BLAST SYSTEMS AND GAGES

The increasing use of air-blast gages is well warranted because the ginner can now keep informed regarding nozzle pressures during operation, reduce his energy requirements, and in many instances better preserve the quality of the ginned lint.

Two distinct forms of air-blast gages are available, one for portable use on individual gin stands and the other for stationary or permanent observation at some accessible place in the gin-floor operating region.

The portable gage (fig. 17) requires the material shown in table 4.

The instrument board may be either of hardwood or softwood and should be finished all over. It may be varnished to prevent warping. The glass tubing is the kind of plain tubing used in high-school chem-

TABLE 4.—*Material required for a portable air-blast gage*

Number required	Material	Description
1	Wood	Instrument board, ¾ by 3 by 24 inches.
2	Glass	Tubing, ¼ inch inside diameter by 22 inches long.
1	Copper	Tubing, ¼ inch inside diameter by 24 inches long.
1	Rubber	Tubing, for bottom of U, ¼ by 4 inches long.
1	Rubber	Tubing, ¼ by 60 inches.
1	Wood or metal	Scale, in inches.
4	Sheet tin	Straps, to fasten glass tubing.
8	Metal	Screws for clips, to suit.
2	Metal	Screws for scale, to suit.
8	Felt	Packing strips for glass and straps.
	Shellac	For cementing rubber tubing to glass or copper.
1	Paper	Dust cap with pinholes.

istry classes and is usually obtainable at drug stores or supply houses. Where possible, the sharp edges of these tubes should be rounded off by using a bunsen burner or gas flame.

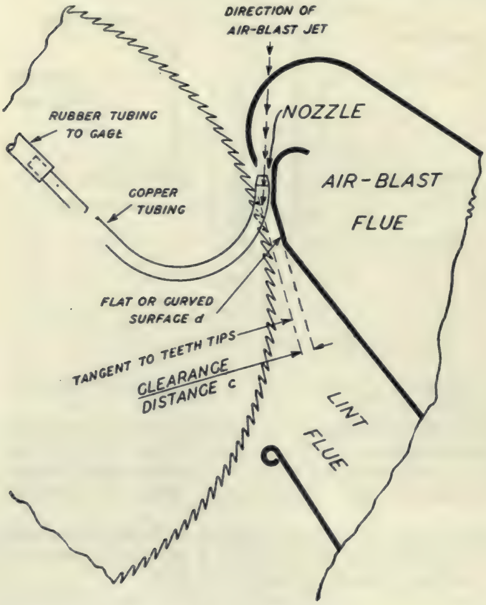

FIGURE 18.—Position of tip of copper tube for checking air-blast nozzle pressure.

The copper tubing should be of straight material, with the tip finished as shown in figure 18. The amount of binding required will depend upon the make of cotton gin.

The other items are self-explanatory.

Before putting on the dustcap, water, colored with dye or red ink, is put into the U-tube with a medicine dropper.

The level of the liquid in both tubes should be brought to the zero line of the scale. If the liquid evaporates, or if difficulties in filling the U-tube prevent bringing the liquid to the desired level, then the scale may be moved to the desired position by means of the slots and adjusting screws.

For air-tightness it is best to shellac all joints between glass and rubber, and between copper and rubber, before slipping the rubber tubing into place.

To use the gage, first see that it is plumb and that the surface of the liquid in both glasses is at the zero line. Then hold the tip of the copper tubing so that it almost touches the nozzle of the air-blast gin, as shown in figure 18. The air blast must blow into this tip in a straight line. Either end of the gin stand may be used in taking the reading, but both ends of any gin stand should give the same reading, and all gin stands in any one battery should read reasonably alike if the air-blast piping is correctly installed.

When the jet of air from the gin nozzle is blowing into the tip of the copper tube, the colored liquid in tube *a* will rise above the zero line, while that in tube *b* will fall an equal distance.

The total difference in inches between these two levels is then computed from the readings on the inch scale. For instance, if the liquid rises in *a* to a distance of 6½ inches above the zero and falls in *b* 6½ inches, the nozzle pressure is 13 inches of water, or the sum of the two readings.

If the nozzle pressures are too low for satisfactory operation, it does not necessarily mean that the air-blast fan must be speeded up. Other mechanisms in the ginning plant may be at fault, such as gin flues, air-blast piping, and nozzles. The gin flues which supply the nozzles may not be airtight, may be choked up, or may be loose at some point near the nozzles. The air-blast piping may also be leaky, may have too many bends and restrictions, or may be choked with fly and foreign matter. The nozzles should be kept straight and free from chokage and should be adjusted so that they are parallel to the saw cylinders and the correct distance away from the tips of saw teeth. This position depends upon the make of gin and angle at which the air blast is intended to blow against the saw teeth.

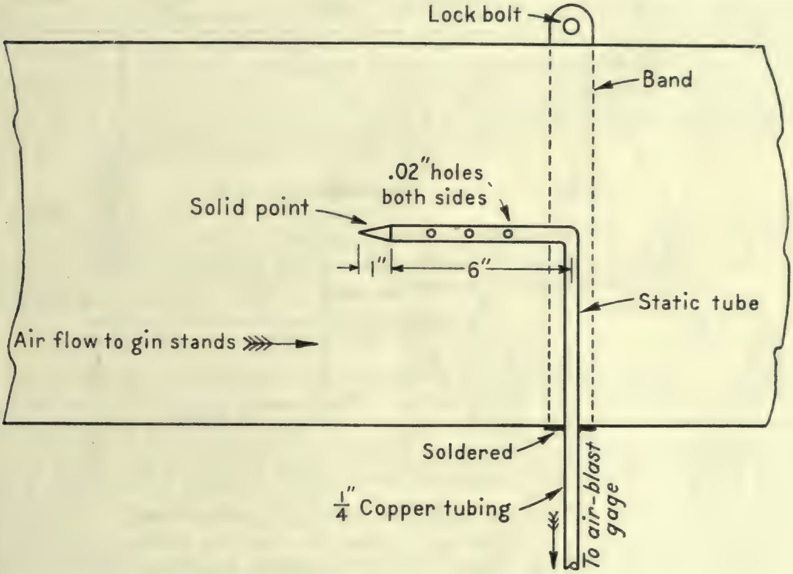

FIGURE 19.—Details of static tube and installations.

In figure 18 the clearance between nozzles and tips of saw teeth is usually measured at *c*. This is taken on the curved or flat surface, *d*, below the nozzle opening. It is advisable to adjust this distance to suit the pressures, atmospheric conditions, and kinds of cotton handled.

The stationary type of gage is identical with the portable one except for the copper tubing which is to be shaped and installed in the air-blast-fan discharge pipe as shown in figure 19.

It is essential that this copper static tube be placed at the center of the air pipe and that the tip points toward the fan, that is, into the air current. The rubber tubing is usually longer than that for the portable gage, or it may be dispensed with entirely if metal piping of copper or iron is run to the gage proper. However, the rubber tubing is probably best because it will withstand vibrations without becoming leaky.

Air-blast nozzle pressures can be readily controlled by changing the area of the fan intake, and the stationary air-blast gage should be positioned so that pressures may be observed while adjusting the control device. Figure 20 is a sectional view through fan intake and screen box, showing the air-blast pressure control devised at the ginning laboratory. This arrangement gives the ginner fingertip control at all times without the necessity of changing fan speed. On sunny days with dry cotton the air-blast pressure may be reduced as low as 10 inches on the water gage; damp weather and wet cottons may necessitate a higher pressure to get the best ginning.

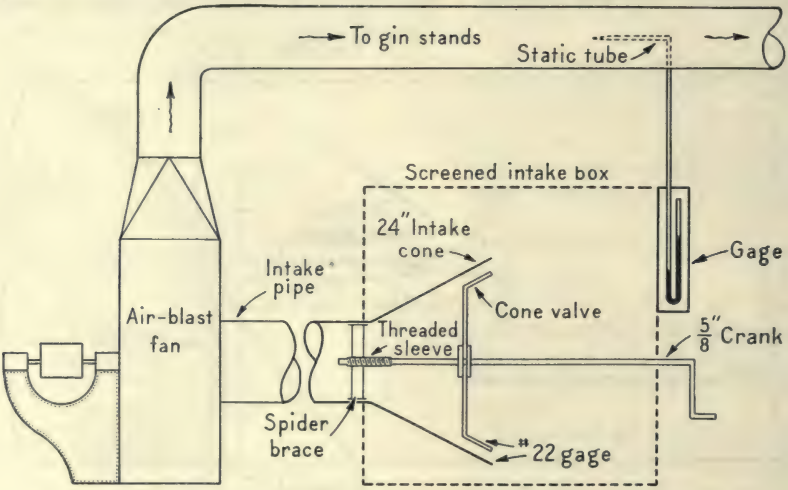

FIGURE 20.—Features of the Government-designed air-blast fan-intake control and gage.

Where a slide damper is used instead of the cone on the intake pipe, it should be placed as far away from the fan as possible, to minimize cavitation and air eddies that tend to prevent uniform entrance of the air into the fan housing. It should also be borne in mind that slide dampers do not regulate air volume in exact proportion to the size of the opening. In other words a half-open damper does not reduce the air volume to 50 percent of that obtained by a full opening. Adjustment of the damper by observation of the air-blast gage will, however, enable the ginner to obtain the desired pressure for best operation.

If it becomes necessary to speed up an air-blast fan, it is important to remember that capacity varies directly with the speed, that pressure varies with the square of the speed, and that power varies with the cube of the speed. For example, in supplying a 3–70 outfit suppose we have a fan delivering 3,868 cubic feet of air per minute at 1,404 revolutions per minute with 11.7 horsepower and a pressure of 11 inches on the gage. By speeding up the fan to 1,520 revolutions per minute, we increase the horsepower to 14.8 and the pressure to approximately 13 inches and the delivery of air to 4,187 cubic feet per minute.

These fan-relation ratios may be stated as follows:

$$\frac{\text{Original volume}}{\text{Final volume}} = \frac{\text{Original speed}}{\text{Final speed}}$$

$$\frac{\text{Original pressure}}{\text{Final pressure}} = \frac{\text{Original speed squared}}{\text{Final speed squared}}$$

$$\frac{\text{Original horsepower}}{\text{Final horsepower}} = \frac{\text{Original speed cubed}}{\text{Final speed cubed}}$$

The air-blast fan is, at best, a rather inefficient pump. Its intake should therefore be arranged so that air will flow smoothly into the casing and so that its discharge piping is as simple as possible. Control of volume and pressure is much more economical on the inlet than on the outlet of these fans, and for this reason it is not good practice to insert any dampers in the fan discharge.

GIN-MACHINERY AUXILIARIES

The profitable operation of a cotton gin frequently depends in part upon such auxiliaries as the power, bearings, belts, pulleys, and other pieces of equipment; hence they should be selected with care.

POWER AND MOTIVE UNITS

The principal characteristics desired in cotton-gin motive units and power service are constant speed, ample capacity to handle overloads, durability or long life, and cheapness in operation and maintenance. Each of the various forms of motive unit now available has significant advantages and disadvantages. The most common sources of power are, of course, electric motors, and steam, Diesel, gas, and gasoline engines.

In determining the most desirable type of motive power for a given installation, consideration must be given to the first cost of the equipment, the cost of fuel or electric energy to operate it, the cost of lubrication, kind of labor needed, expense of maintenance, probable length of life, and decrease in power capacity resulting from use.

The amount of electrical energy required will vary considerably, depending upon how constant and intermittent loads are handled, and upon the extent of the use of fans and other accessories. In electrically operated gins, it is highly advisable to separate the various loads so that intermittent work of pumps, presses, and seed loading into cars or trucks will be done with separate motors rather than from the main motor. Electric-power companies usually give consulting and testing services to their patrons, and gin owners may use such services to obtain economical operation.

Steam gins appear to be decreasing in number because they are not conveniently adaptable to intermittent and prompt service and because supplies of cheap fuel are disappearing. Furthermore, some State regulations are increasingly stringent in that steam boilers are now subjected to periodic inspection and licensed operation. However, modern steam engineering has made such rapid improvement in construction and practices that large commercial gins might obtain very effective and economical installations. Where steam is available for ginning cotton it has the added advantages of being on hand for conditioning equipment and for extinguishing fires.

Diesel, gas, and gasoline engines have much to commend them for the seasonal service of cotton ginning. In selecting such engines the purchaser should allow for a liberal margin in power over that which is actually required. Most manufacturers now list their engine ratings at the maximum power produced when the engines are new, and the purchaser should bear in mind that the capacity will decrease with service.

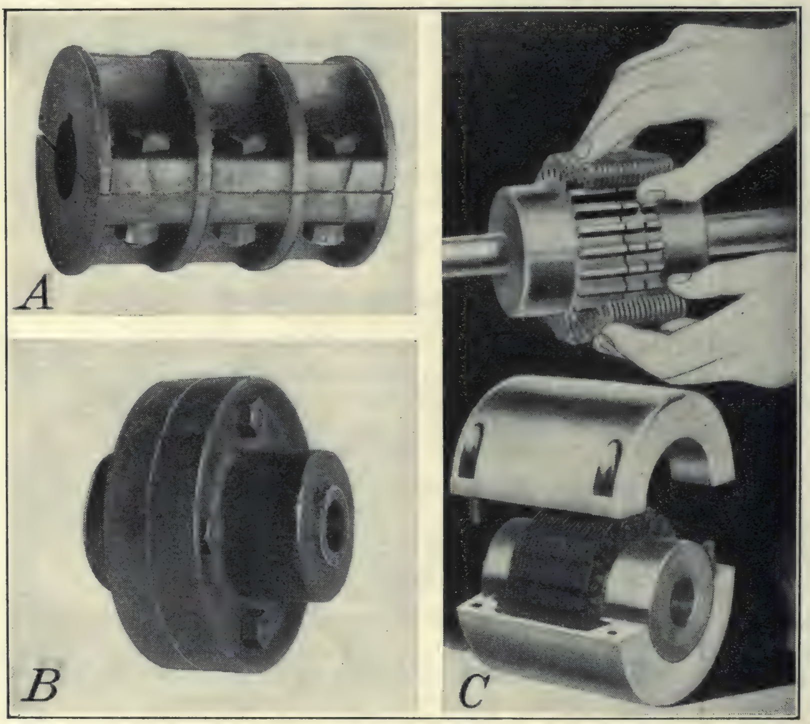

FIGURE 21.—Safety shaft couplings: *A*, Marine type; *B*, flange type; *C*, flexible-chain type.

POWER TRANSMISSION

All shafting and bearings consume power, and ball or roller bearings should be substituted wherever possible for plain bearings. All such frictionless bearings must be carefully guarded against damage from grit and dust, and approved commercial types designed for such service should be selected. The alinement of shafting and bearings is important to the uninterrupted and economical operation of any gin and necessitates suitable pedestals or other anchorages for the bearings. For two-story gins, concrete pedestals are desirable on the ground floor but for single- or one and one-half-story gins, adjustable iron floor hangers are frequently preferable. Where the shafting is built up of individual lengths coupled together, it is much better that the drive should be made at the center rather than at one end so that torsion and breakage may be minimized. Couplings should be of the safety types shown in figure 21.

In making new installations of shafting with the accompanying belting and pulleys an endeavor should be made to eliminate as many belts and pulleys as possible, because they constitute a possible source of trouble and power loss. Flat belts of adequate center lengths are approximately as efficient as V-belts; but V-belts, when properly selected, can be employed to make very neat, short, safe drives; and under certain circumstances, can be utilized even for right-angle drives.

In selecting either flat or V-belts, the actual load must be kept below the maximum capacity of the belt selected. It is far better to have oversized flat belts or a few extra V-belts in any drive than to face the delay, expense, and possible damage that may arise through the use of undersized belts. Seasonal service at cotton gins enables operators to use composition beltings of various kinds, but the greatest economy does not necessarily lie in the cheapest belt; and the duty of each drive should be carefully considered in specifying the kind, capacity, and other details of the belt involved.

SEPARATORS AND DISTRIBUTORS

The air handling systems in cotton gins are usually operated in conjunction with separators, pneumatic chutes, distributors, lint flues and condensers. The general requirements for the seed-cotton suction and air-blast piping have already been discussed. The allowance of 800 to 1,000 cubic feet of air per minute per gin stand previously made for the unloading system does not include an estimated 1,200 cubic feet per minute for air leakage and losses at the piping joints and separators, which frequently have faulty vacuum wheels or poorly fitted distributor seals. Improved forms of separators now on the market employ revolving screens and vacuum wheels which handle much damper and trashier cottons with lower air losses and fewer chokages than will the older stationary-screen types. Various types of modern separators are shown in figure 22. The use of revolving vacuum wheels in connection with the separators has proved to be superior to using a belt distributor with solid flaps in order to obtain an air seal. A vacuum wheel is also desirable when other than belt forms of distributors are used, or when one separator is used for two purposes as in several kinds of modern drying installations.

Distributors of various forms have comprised the backbone of ginning outfits since the introduction in 1883 of air piping for handling seed cotton. The marked improvement in separators that began about 1928 was accompanied by the immediate development of better distributors—the principal forms being those in all-steel design of screw and gyrator type to replace belt and pneumatic-elevator distributors. Screw distributors or conveyors are on the market with both single and double flights, ranging usually from 10 to 16 inches in diameter and making from 100 to 150 revolutions per minute in a sheet-steel trough, in the bottom of which are pivoted change-bale valves to control the feeding of units beneath. Gyrator distributors incorporate a tedding or kicking action through spring-steel wires for moving the seed cotton along a sheet-steel trough to the change-bale valves and overflow.

Modern distributors require little attention beyond periodic lubrication, are rigid and self-alining to a great degree, use less power than belt distributors, and reduce fire hazards.

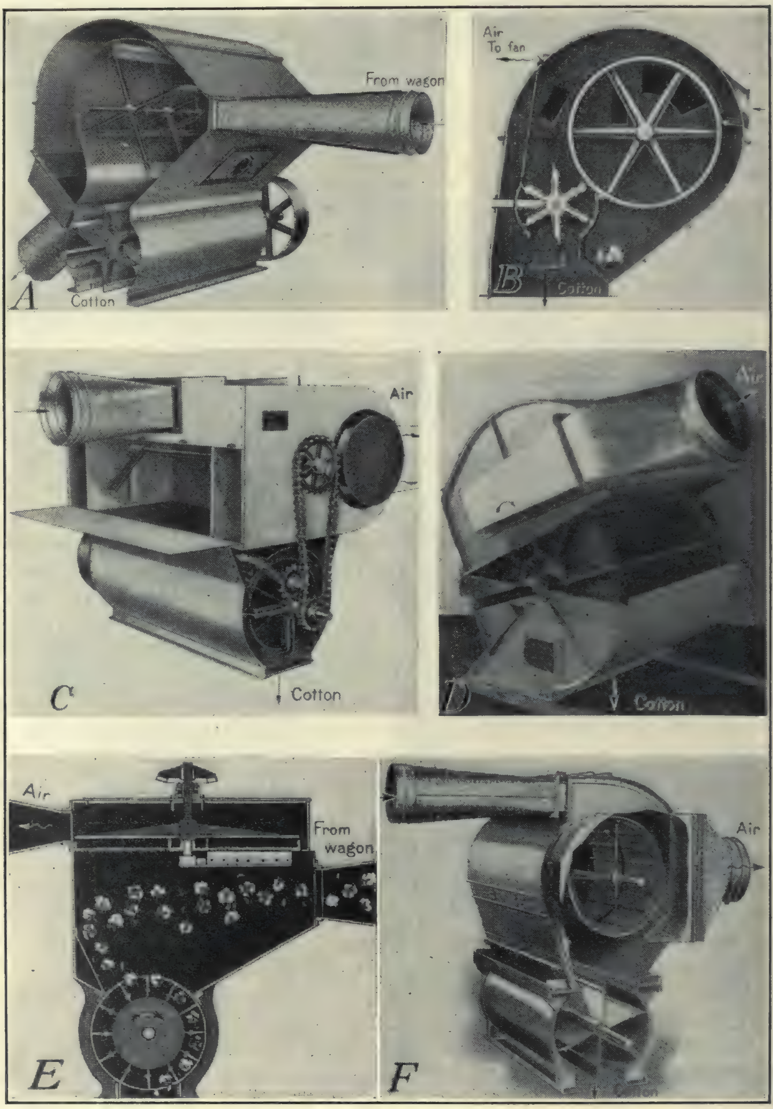

FIGURE 22.—Diagrams of modern types of separators: *A*, Stationary curved-screen type with wiping reel; *B*, revolving cylindrical-screen type with trash conveyor; *C*, Vertical double-perforated-disk type with rotating wiper and suction equalizer back box; *D*, revolving partitioned-cylinder type with end screens on cylinder; *E*, stationary horizontal-screen type with underside suction and rotary wiping cut-off; *F*, revolving drum-screen separator.

LINT FLUES AND CONDENSERS

Lint flues may be located either above or below the level of the operating floor in a cotton gin, as shown in figure 23. Although the majority of lint flues are above the floor, in some recent installations lint flues have been placed below the floor to conserve space.

Dust backs or cleaning screens connected with condensers, when properly installed, have proved a satisfactory aid in removing pin and pepper trash from the ginned lint. They should be cleaned daily, however, and kept in first-class condition.

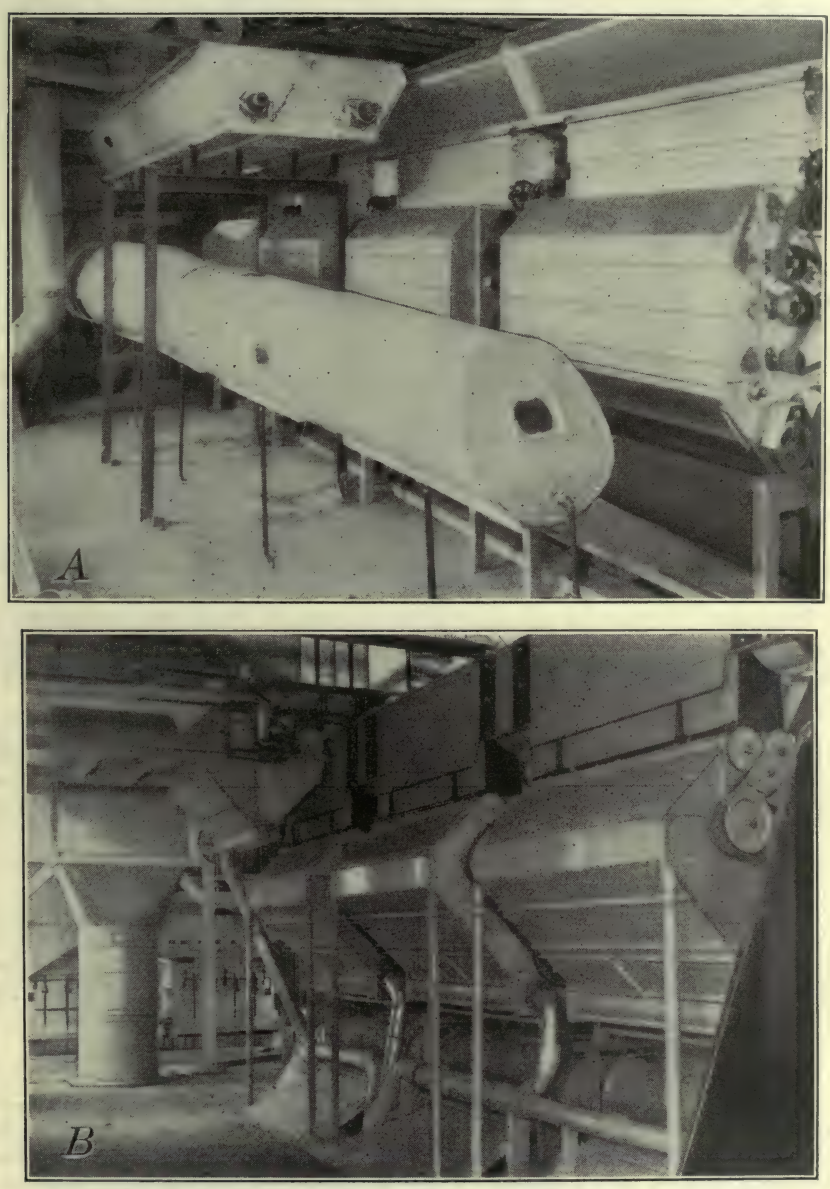

FIGURE 23.—Installations of lint flues: *A*, Above operating floor; *B*, below operating floor.

The maintenance of proper static pressures in lint flues is very important because too much pressure will produce backlash, with its attendant trouble, especially if the condenser is not large enough.

Lint-flue pressures should not exceed one-half inch for brush gins or three-fourth inch for air-blast gins. Where ginners install only a part of the gin stands necessary to begin operation of a new gin, it is desirable to obtain the proper size of lint flue for the full number and install the stands nearest the press first so that extensions of the lint flue can be made if additional stands are installed.

All-steel condensers may now be obtained for either up or down discharge, and when of adequate size and properly installed, should give little trouble from prevailing winds if properly shielded by dust caps or a dust shed. Diagrams of typical up-draft and down-draft condensers are shown in figure 24.

PRESSES, TRAMPERS, AND PUMPS

The trend in modern cotton-gin presses has been toward all-steel construction, hydraulic pressing, and mechanical tramping. Double-box types have supplanted most of the single-box presses in all except a few of the older small gins and are on the market in up-packing and down-packing designs.

Hydraulic power for pressing has to a large extent replaced screw power because it is simpler, more powerful, and more dependable. With it, presses are readily adaptable for either up packing, such as is usually found in one and a half-story and two-story gins, or for down packing, as found in one-story gins where the bales are tied out almost at ground level.

Hand-controlled trampers are obsolete, and very few steam or hydraulic ones are being purchased although their mechanical features have through years of experience become very dependable.

Modern double-box presses have departed from the drop-down swinging doors that require counterweights, using instead improved side swinging doors with hand-wheel locks and other safety attachments.

The form of hydraulic pump used in modern gins depends largely upon the kind of power used, and may be a motor-driven individual unit or may be belted to the main-line shaft. As a rule, triplex pumps are desirable because of their smooth operation and freedom from trouble. They may be either vertical or horizontal and may be provided with either tight and loose pulleys or V-belts so that they may run steadily or be idle between the pressings of bales.

It is generally advisable in motor-driven gins to operate the press pump with a separate motor so that variable peak loads are not imposed upon the main motor and so that power consumption may be reduced during periods when the pump is not needed. Figure 25 illustrates such a pump.

SCALES FOR WAGONS, BALES, AND SEED

Methods of weighing seed cotton, seed, and ginned lint differ widely in different sections of the country. Some gins employ only one set of wagon scales for weighing everything, while others utilize wagon scales to weigh the incoming seed cotton and outgoing wagonloads of seed, the bales being weighed on yardarm scales placed near the press. The most modern installations employ (1) a wagon or truck scale for weighing incoming loads of seed cotton and outgoing loads of seed; (2) platform or yardarm bale scales located adjacent to the press; and (3) special seed scales located between the gin stands

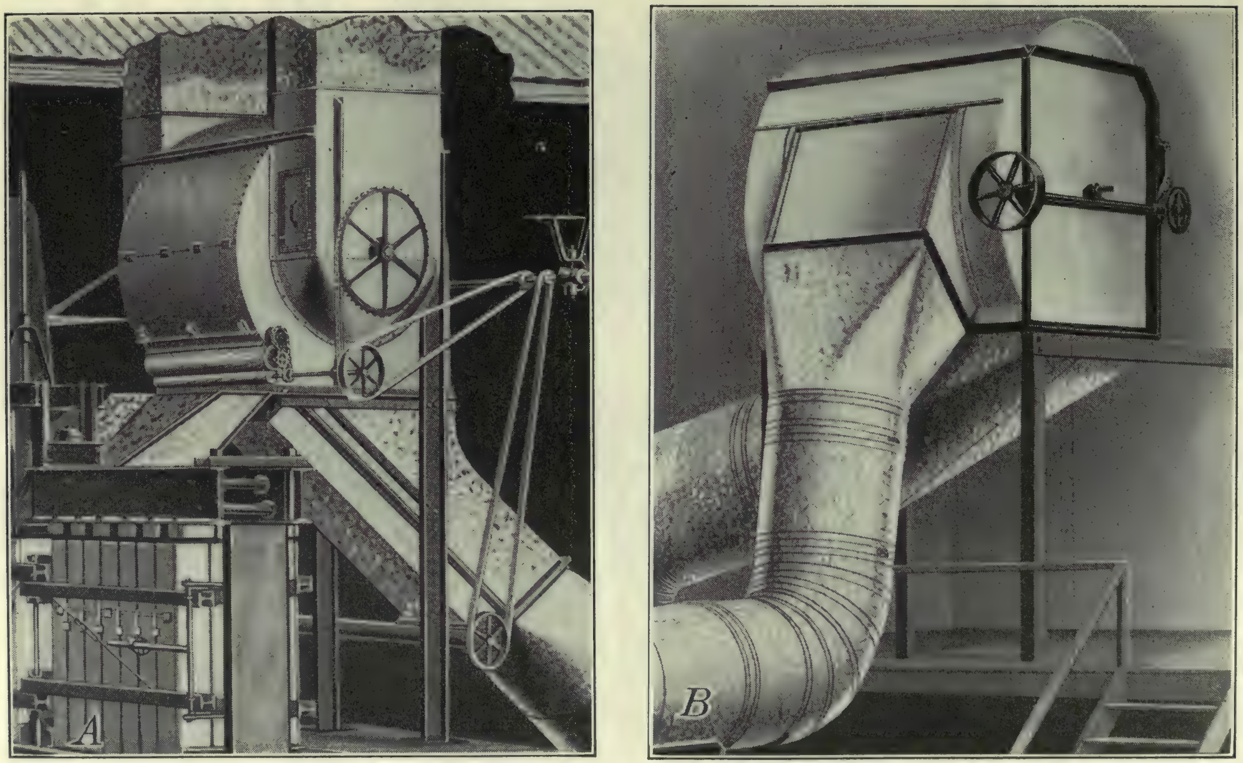

FIGURE 24.—*A*, Up-draft condenser; *B*, down-draft condenser.

and the press so that the weight of seed per bale can be obtained during the ginning process. Figure 26 is from a photograph taken in a single-story gin, showing the method of installation of a modern seed scale. After the seed has been weighed in the seed scales, it is conveyed by vertical lifts to the transfer conveyor that carries it either to the storage, to the railroad car, or to the wagon bin. Three forms of lifts are customarily employed; namely, bucket elevator, air and screw.

APPEARANCE OF GINNING ESTABLISHMENTS

The buildings and grounds of a modern ginning establishment present a clean, businesslike appearance in contrast to the unkempt, bankrupt atmosphere of obsolete gins. Trash and refuse are not allowed to accumulate; surplus machinery is neatly stored under shelter; condenser vents are kept free from fibrous streamers of dirty lint; and paint is applied for appearance as well as preservation.

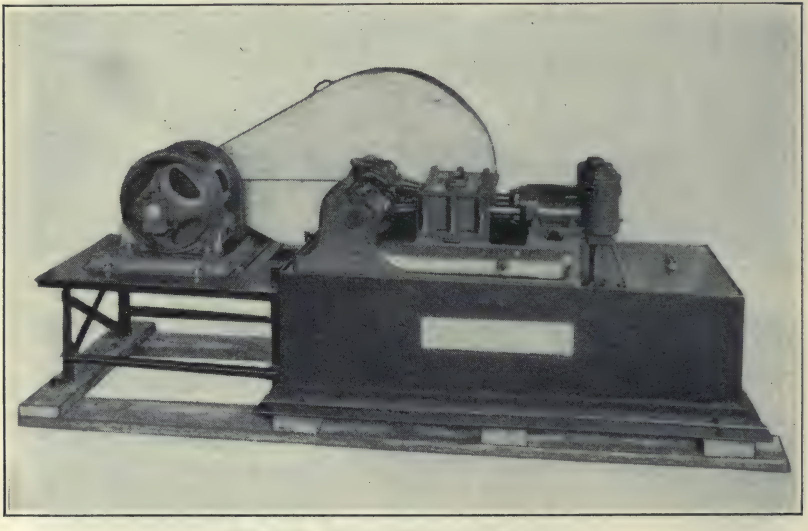

FIGURE 25.—Motor-driven hydraulic pump.

Muddy lots are seldom found at modern gins, and customers may drive their loads on graveled roadways beneath welcome shelter sheds to await their turns. Good drinking water and clean toilet facilities add greatly to the comfort of the customers.

For metal buildings in the South, aluminum paints with oil or asphaltum bases are probably the most durable, if the surfaces have weathered for a few months before the paint is applied.

For wooden surfaces, metallic oxide paints in reds, browns, and greens appear to be very durable, and these colors are generally available in composition shingles for such structures as shelter sheds and storage buildings.

Planting trees and shrubs about the gin lot adds greatly to the attractiveness of the place.

EXAMPLES OF MODERNIZATION

The essential features of a modern cotton gin and the improvements that can be made in existing gins have been discussed. Some of the more popular features and improvements are illustrated in succeeding figures. One of the most important trends in modernization is the installation of conditioning equipment for drying green, damp, or wet seed cotton. Interior views of gins before and after the installation of vertical cotton driers, a unit extractor system of drying, and a conveyor-distributor drier are shown in figures 27, 28, and 29, respectively. The arrangement of the vertical drier between the separator and belt distributor has the advantages of simplicity of installation

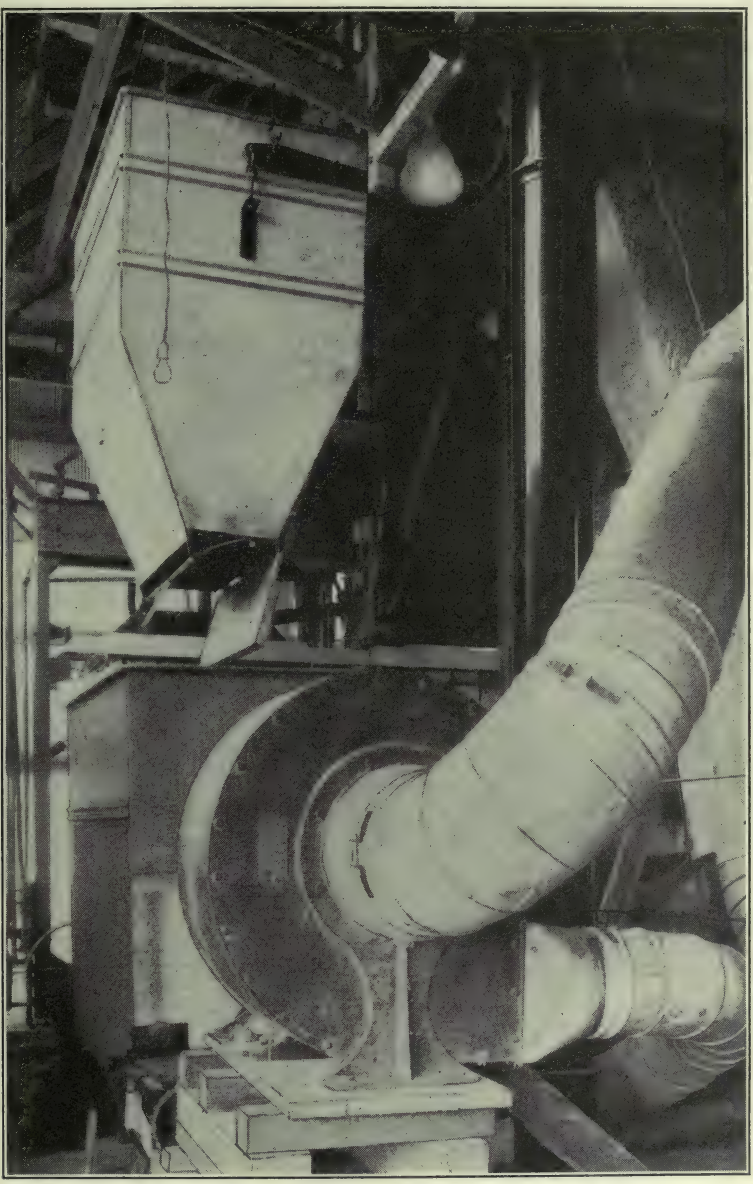

FIGURE 26.—Seed scales employed in a modern cotton gin.

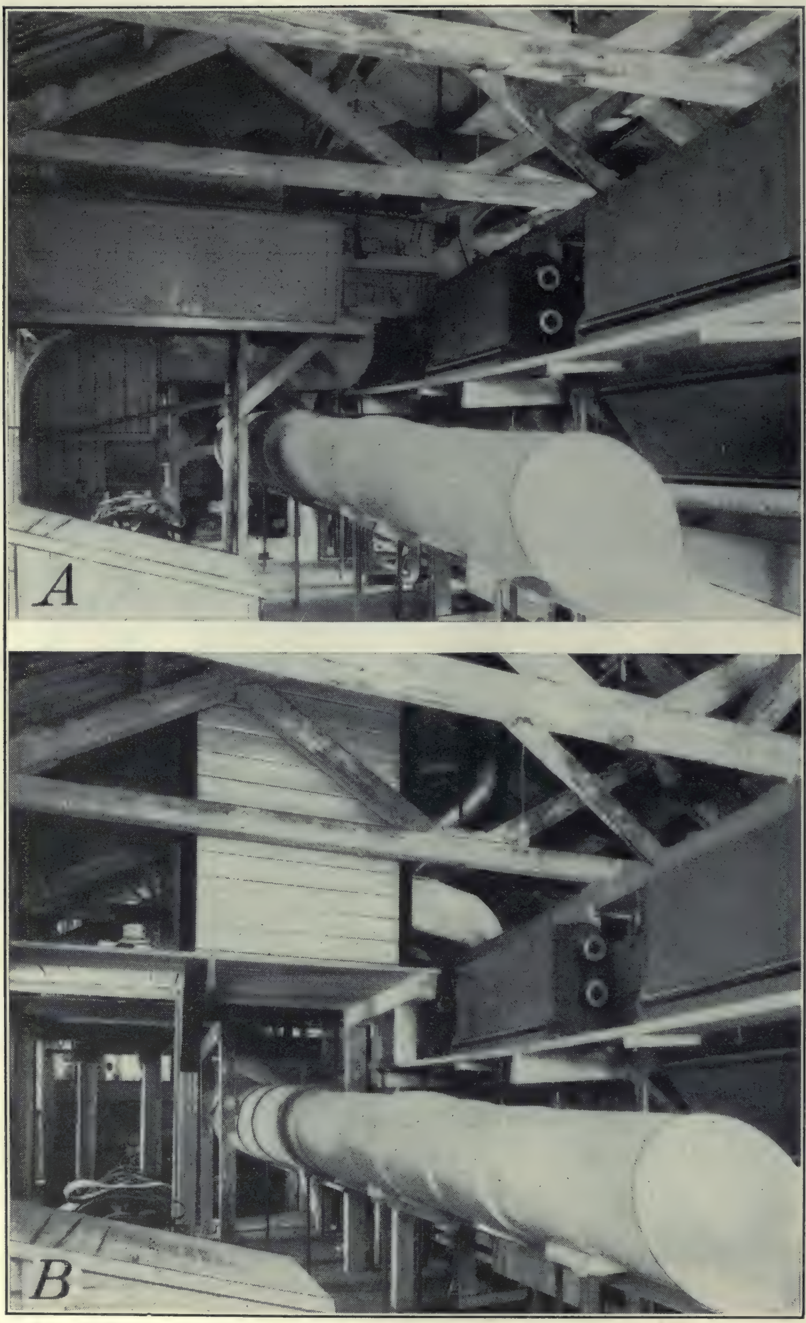

FIGURE 27.—Gin outfit (*A*) before and (*B*) after the installation of Government-designed vertical drier.

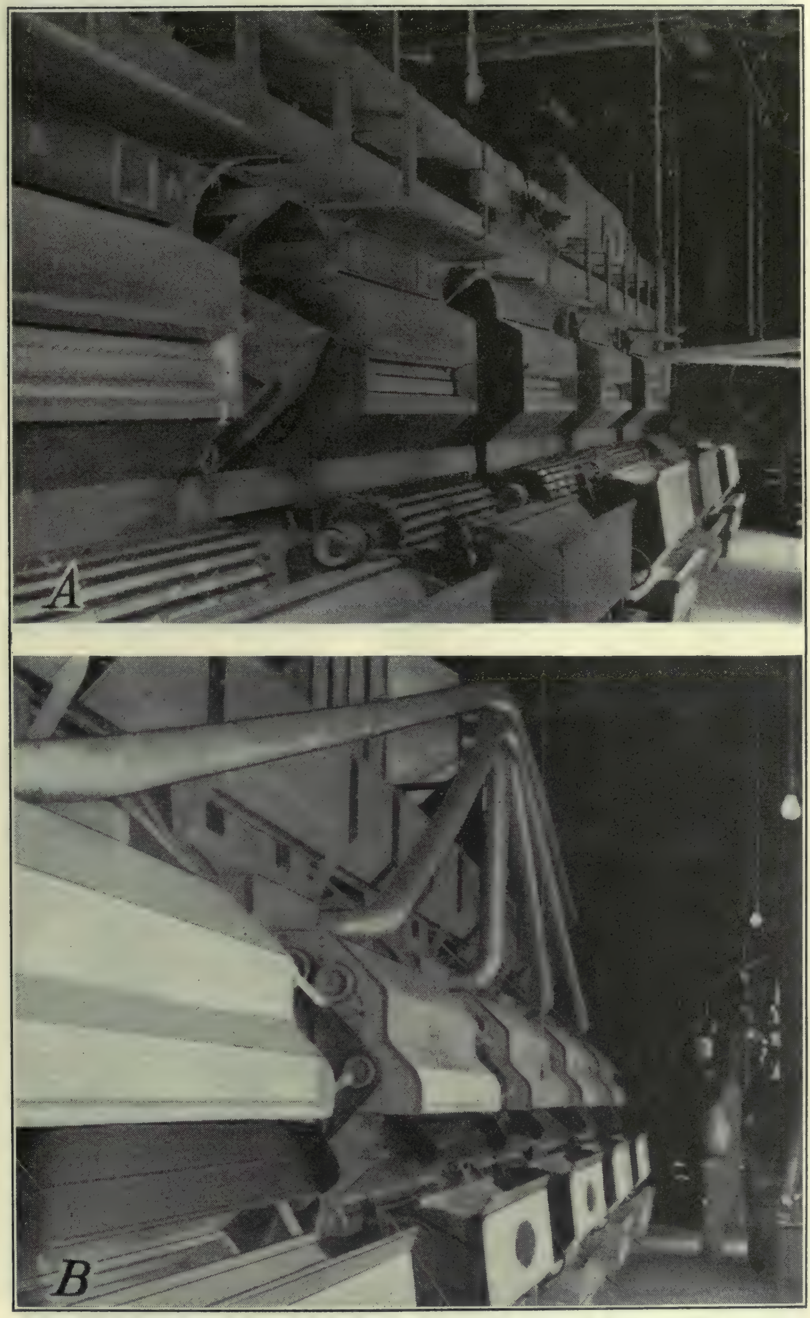

Figure 28.—Gin outfit (*A*) before and (*B*) after the installation of unit extractor drying system.

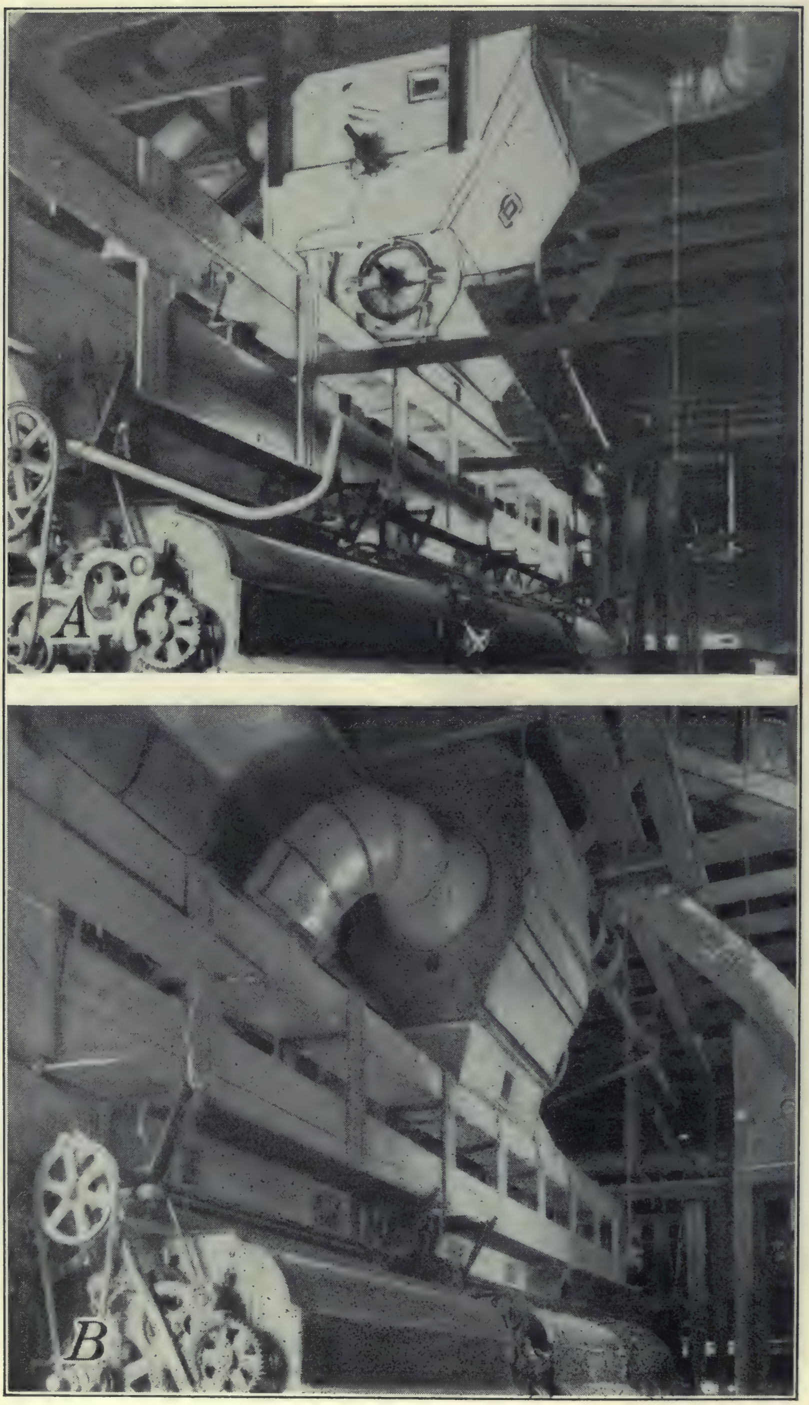

FIGURE 29.—Gin outfit (*A*) before and (*B*) after the installation of a conveyor-distributor drier.

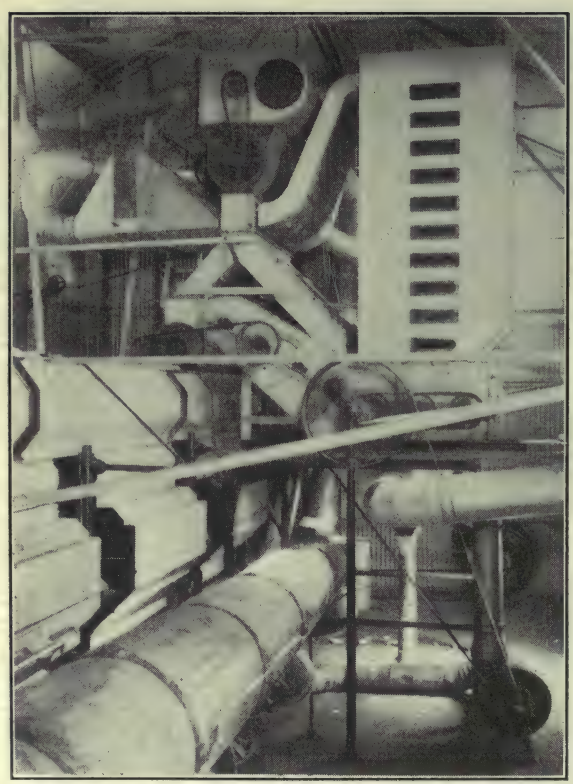

FIGURE 30.—Gin outfit with application of hot air to an overhead cleaner at top of drums.

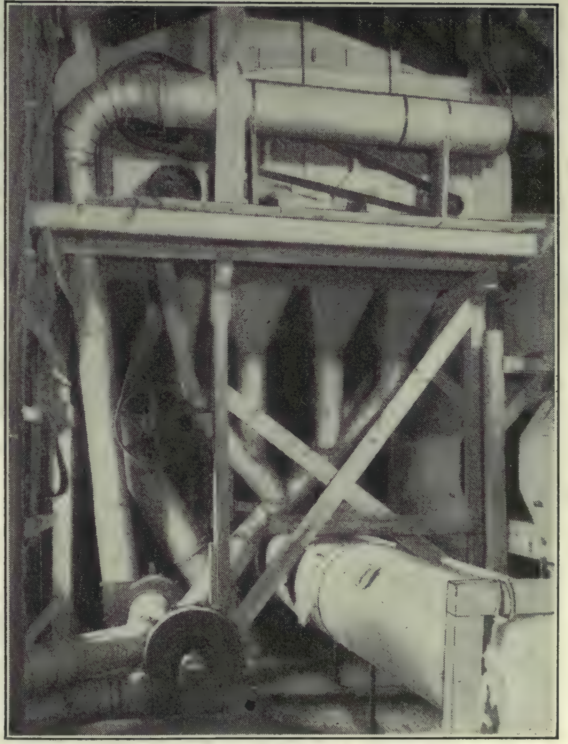

FIGURE 31.—Gin outfit in which hot air is applied to the cleaner at the ends and tops of paddle-wheel cylinders.

and economy of operation. With the other systems, belt distributors are generally replaced by conveyor distributors. If there already is a conveyor distributor the additional units shown can be added conveniently, to make a very compact drying system.

Another method of combining cleaning and drying facilities economically is illustrated in figure 30. Like the drying system previously mentioned, this system may obtain heat from steam coils or engine waste heat.

A factory-built installation of an overhead paddle-wheel type of cleaner with a drying attachment on each side is shown in figure 31.

Figure 32 illustrates a comparatively new type of factory-built drying system wherein the cotton is passed through a rotating screen cylinder with built-in ribbon conveyor, all in an encased chamber to which heat supplied by a hot-air furnace is introduced at various points.

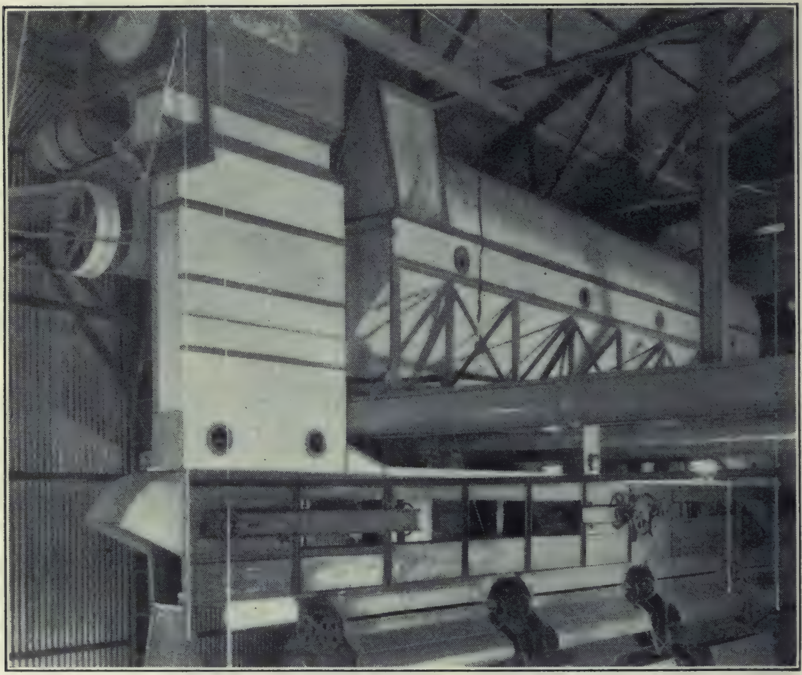

FIGURE 32.—Gin outfit equipped with a ribbon conveyor-cleaner drier.

Figure 33 shows an installation of the multiple-cylinder axial-flow air-line cleaner-drier which has been recently developed by a gin manufacturer. The steam coils are inside the cleaner.

A factory-built, revolving-floor, round vertical-tower drier is shown in figure 34. As may be seen in this picture of a commercial installation, the method of feeding the drier is similar to that employed in feeding some of the stationary-floor vertical-tower driers.

An economical method of applying hot air to air-line cleaners, as developed by the United States Cotton Ginning Laboratory, is shown in figure 35, in which is shown the split suction arrangement supplying

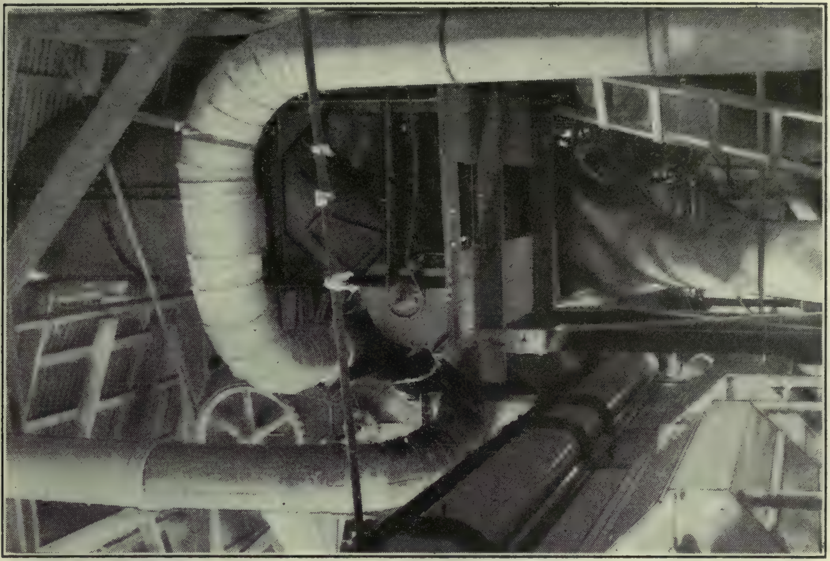

FIGURE 34.—Gin outfit equipped with a revolving-floor, vertical-cylinder drier.

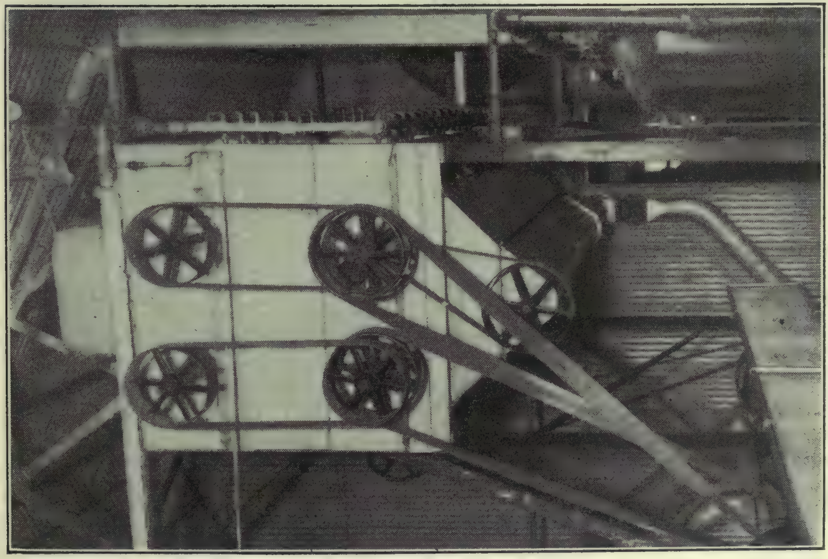

FIGURE 33.—A commercial installation of the multiple-cylinder axial-flow air-line cleaner-drier.

drying air and air for unloading the cotton from the wagon with one fan.

The tendency in recent years in regard to modernization of other units for preparing cotton further before ginning is the installation of unit extractor-feeders to replace the combined performance of more ponderous overhead cleaning machinery and gin-stand feeding equipment. Huller gins are likewise constantly replacing plain gins because they provide an additional cleaning action. Modern gin stands, now being made by all manufacturers, are of all-steel construction instead of wooden construction; and distributing systems of the belt and pneumatic types are gradually being superseded by all-steel conveyor and gyrator distributors. Interior views of an old-style gin outfit and a modern all-steel outfit are shown in figure 36. Thus the modern gin has an all-steel separator and conveyor-distributor instead of pneumatic elevators; unit extractor-feeders instead of cleaning feeders, huller instead of plain fronts; and a direct-connected drive and a minimum of belting instead of an independent saw-and-brush drive and many belts.

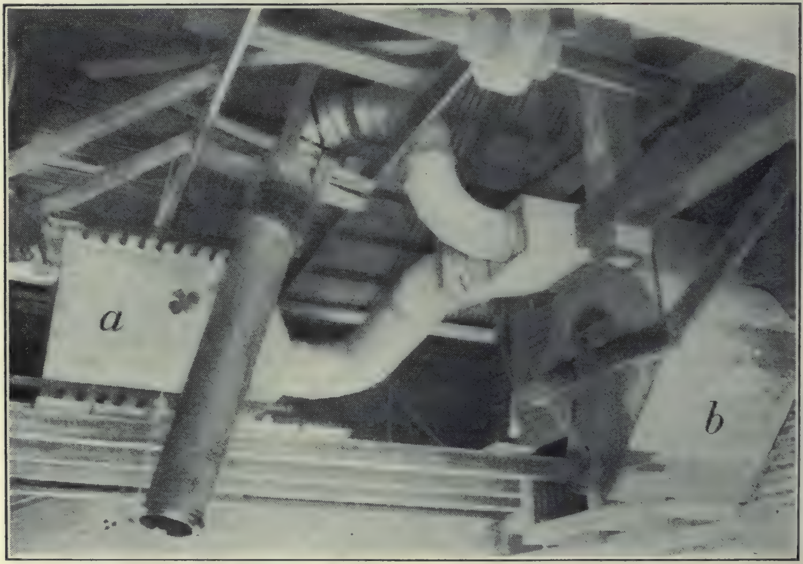

FIGURE 35.—Commercial installation of the Government-designed air-line drier: *a*, Heater coils and split-suction arrangement; *b*, drying chamber.

Modern gins generally have only one floor level, and the press as well as the condenser is of all-steel construction. The old-style wooden press and wooden condenser in a two-story gin and the modern all-steel down-packing press and steel condenser in a one-story gin are illustrated in figure 37.

Ginners are being urged to adopt efficient and economical means for handling seed at the gins. Provisions for handling cottonseed, including the methods of blowing and conveying, are brought out in figure 38.

Need for improvement in gin-building construction has long been recognized; and ginners are beginning to take advantage of the

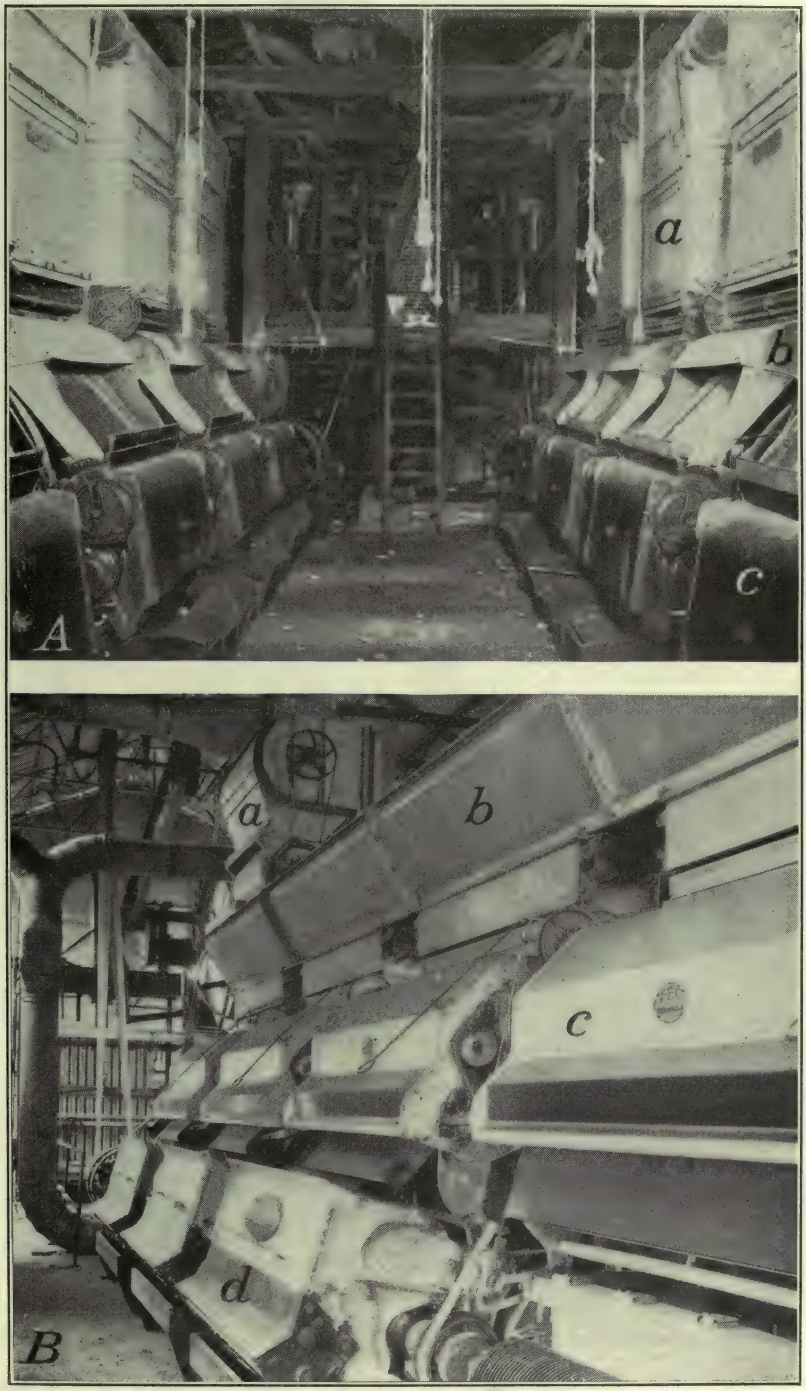

FIGURE 36.—*A*, Wooden gin equipped with pneumatic elevators (*a*), cleaning feeders (*b*), and plain fronts (*c*); *B*, all-steel gin equipped with separator (*a*), conveyor-distributor (*b*), extractor-feeders (*c*), and huller fronts (*d*).

opportunities in this direction. Typical old-time wooden and sheet-iron two-story gin buildings, in contrast with modern brick, tile, concrete, and steel buildings are shown in figures 39 and 40.

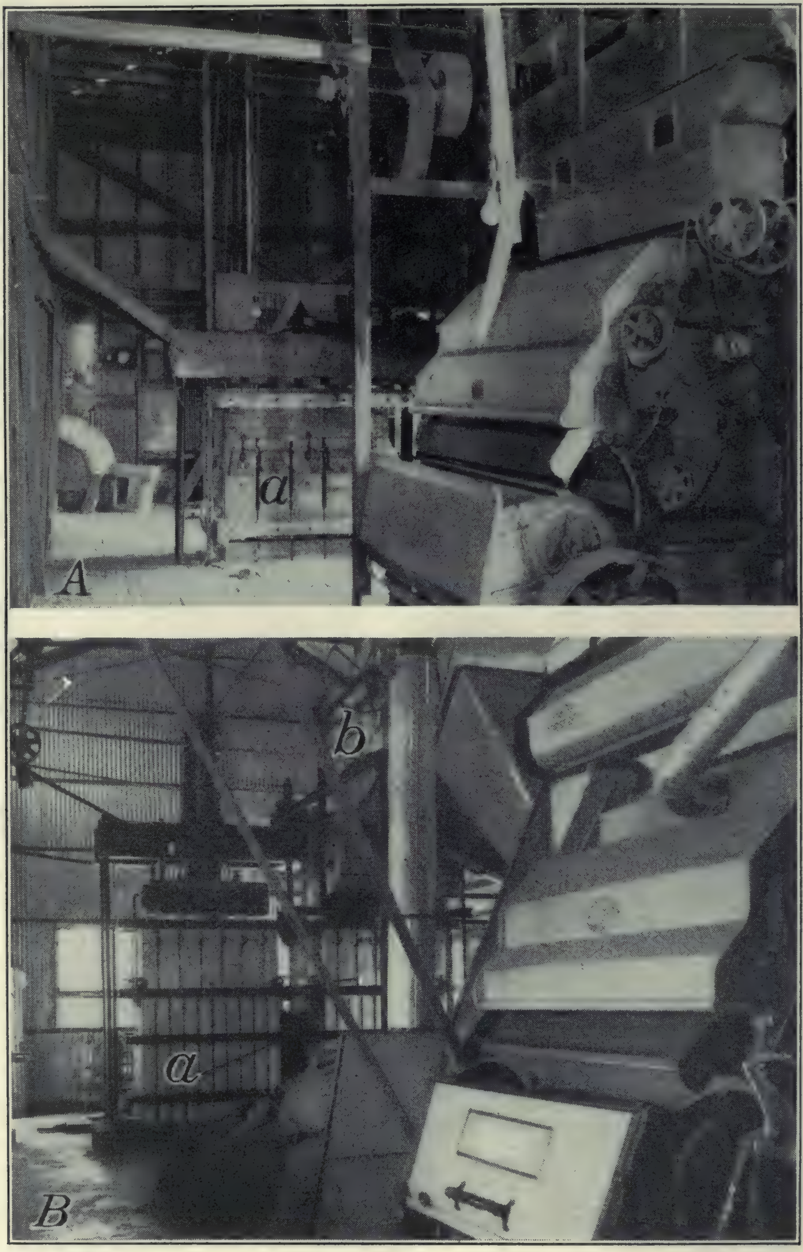

FIGURE 37.—*A*, Two-story gin showing (*a*) an old-style wooden press and a wooden condenser; *B*, one-story gin showing an all-steel down-packing press (*a*) and a steel condenser (*b*).

Progressive ginners find it profitable to have adequate and fireproof facilities for storing seed cotton before ginning and equipment for handling the seed cotton with a minimum amount of labor. An

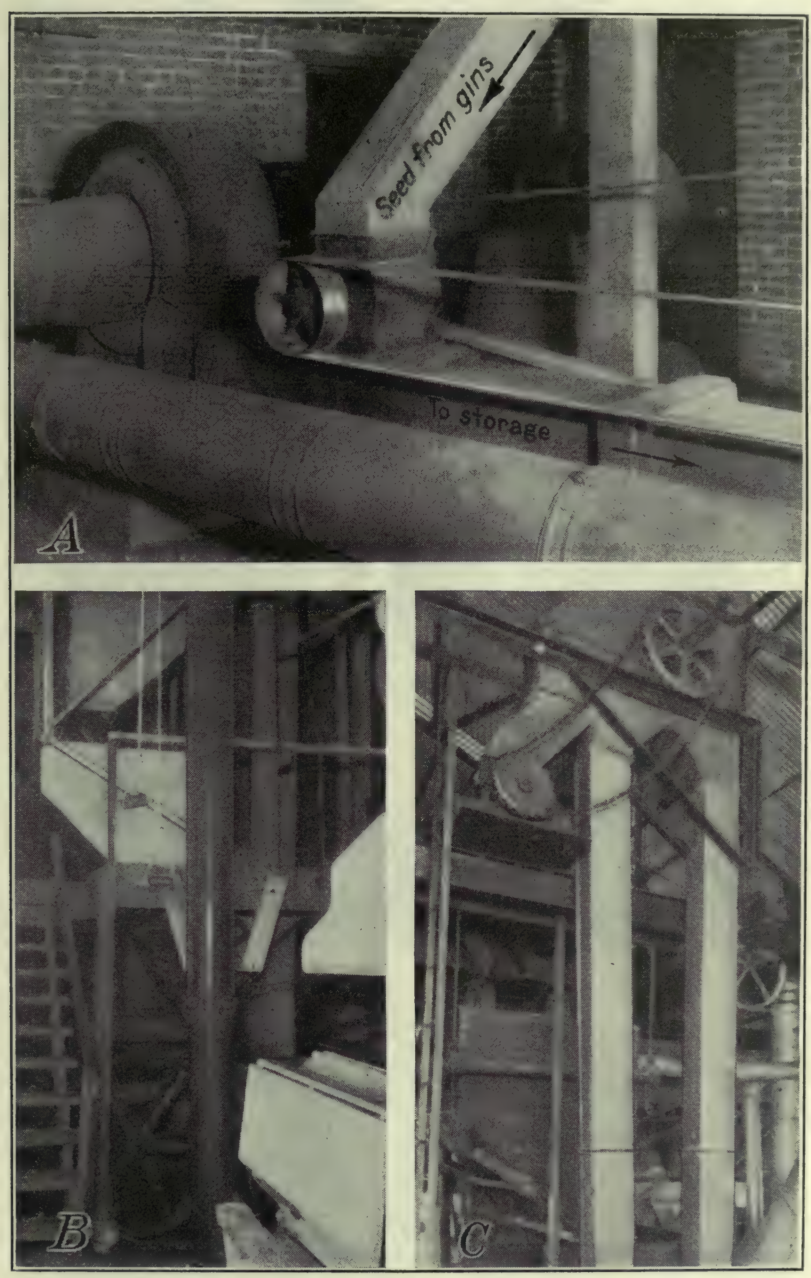

FIGURE 38.—Methods of seed handling: *A*, Seed blowing; *B*, elevating with vertical screw conveyor; *C*, elevating with bucket elevator.

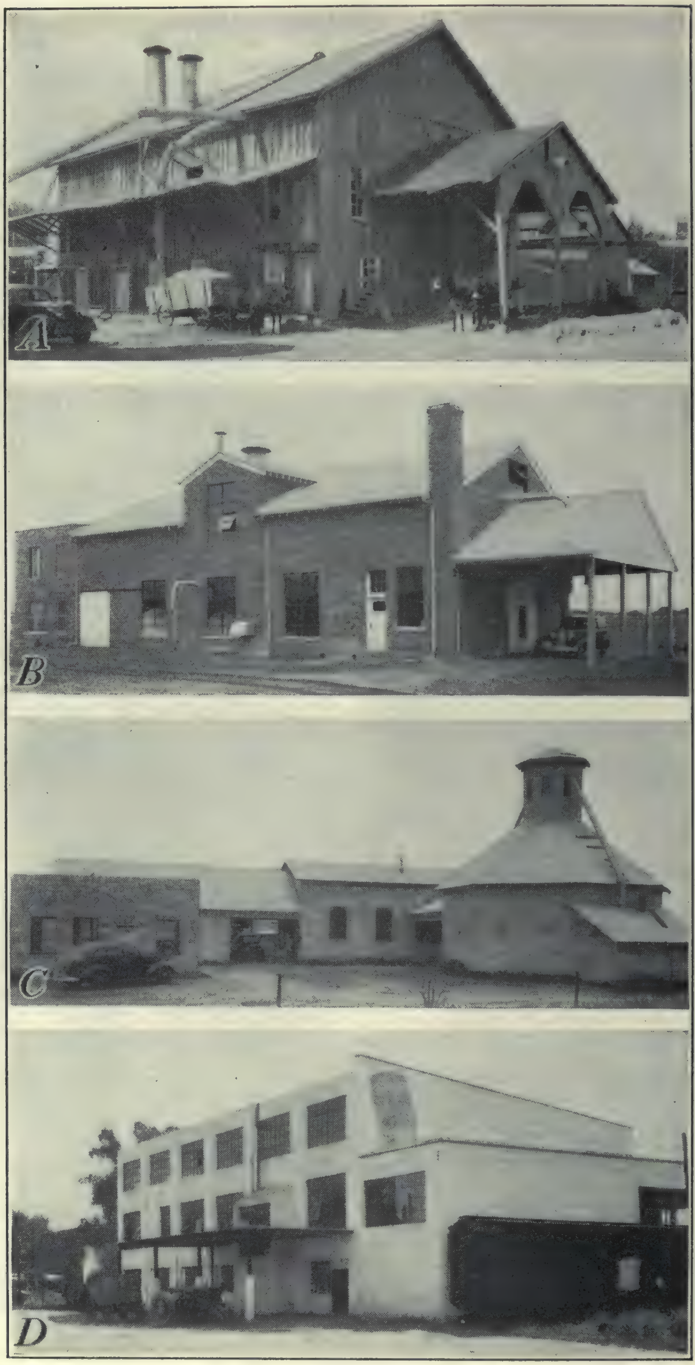

FIGURE 39.—Cotton-gin buildings: *A*, Old-type wooden construction; *B*, brick; *C*, hollow tile; *D* concrete.

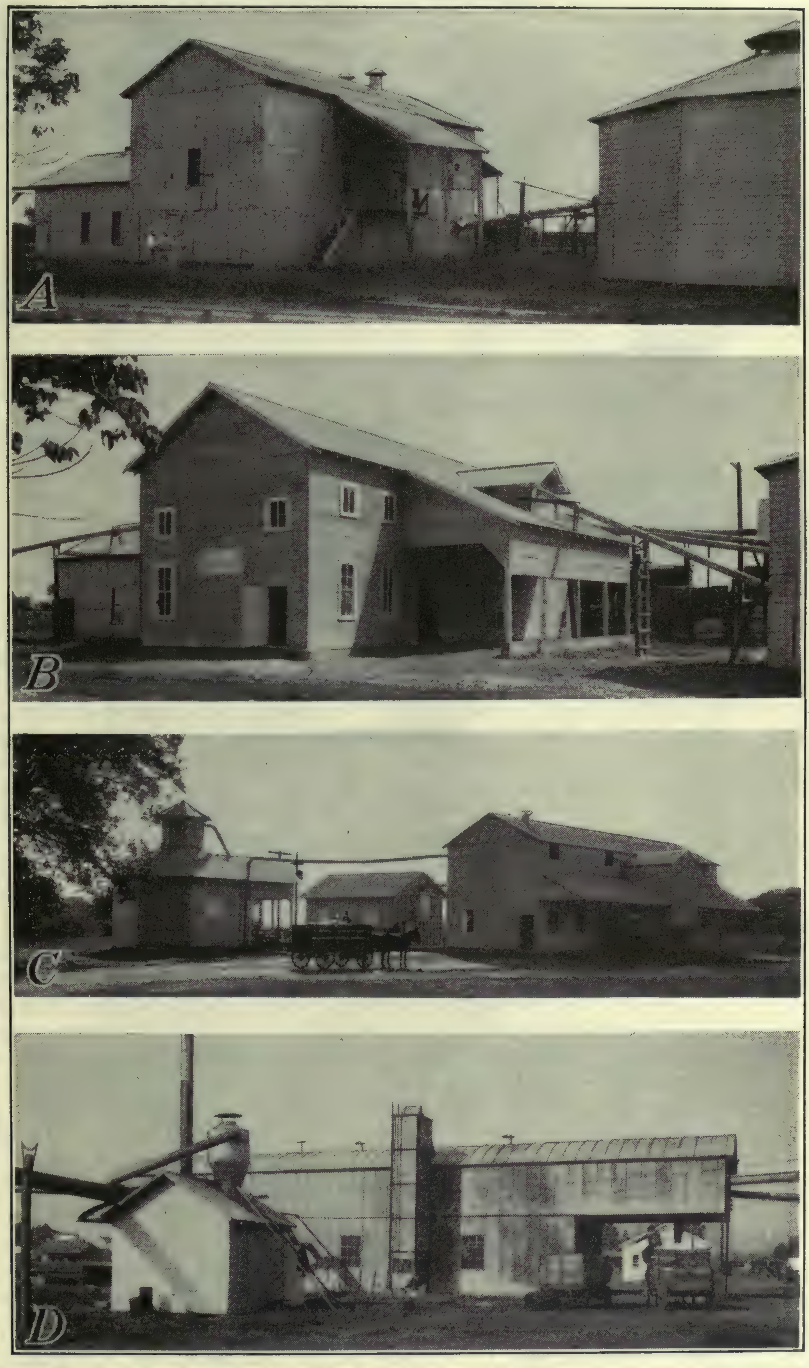

FIGURE 40.—Cotton-gin buildings: *A*, Old-type steel building; *B*, steel with wooden framing; *C*, all steel, inside and outside; *D*, all-steel inside and outside, with bow roof.

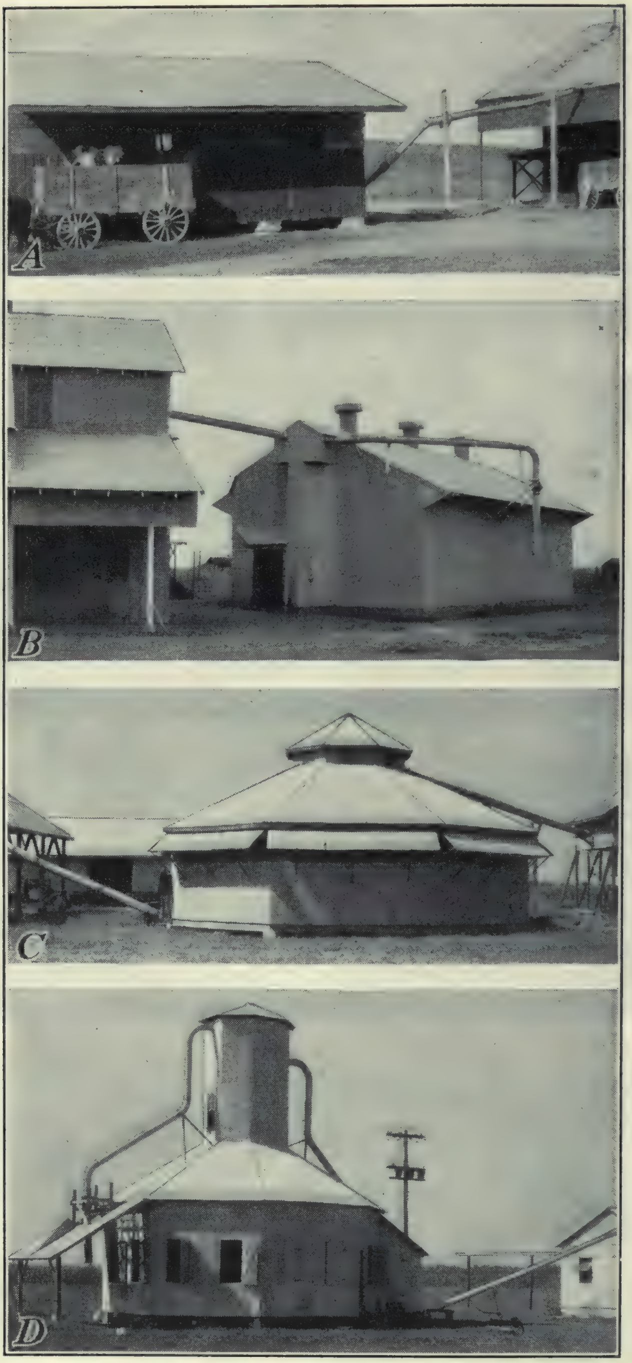

FIGURE 41.—Seed-cotton storage houses: *A*, Rectangular, without unloading facilities; *B*, rectangular, with Rembert-type fan for unloading; *C*, octagonal, with Rembert-type fan for unloading; *D*, octagonal, with pneumatic-dropper unloading system.

inadequately equipped old-style rectangular seed-cotton storage house, as compared with a modern octagonal sheet-metal house fitted with pneumatic unloading system and modern rectangular and octagonal houses equipped with a Rembert-fan assembly for unloading are illustrated in figure 41.

MAINTENANCE OF GINS

LUBRICATION

Good lubrication prolongs the life of the moving parts of cotton-ginning machinery, and the selection of the proper lubricants depends upon the use to which they are to be put.

The value of a lubricant depends upon its film-forming capacity at any operating temperature rather than upon its viscosity alone; hence oils of the highest viscosity are not necessarily the best lubricants. Selection of the lowest viscosity oil that will maintain an unbroken oil film on the bearing surfaces is usually best, because oils of greater viscosity consume more power than necessary in retaining the film and in overcoming the internal resistance of the oil itself. Likewise, the value of greases depends upon the pressures, speeds, and temperatures of the operating parts, as well as upon their body weight and apparent greasiness. Greases are usually more economical lubricants than oil. Other things to consider in lubrication are the location and types of the oil cups or grease plugs. Some bearings are not accessible for greasing or oiling except when the machine is idle and should be of an improved type that will hold enough lubricant to suffice for some time. Thus, bath or ring-oiling bearings are superior to plain friction ones because they have ample reservoirs and do not require constant attention. However, roller or ball bearings require still less attention, and the savings on power will usually more than pay for their installation.

The use of good grades of oils and greases saves money; loss of time due to break-downs and hot boxes is frequently caused by the use of inferior lubricants.

Lubrication charts are now generally available from most oil companies, to serve as a guide in the selection of oils and greases for various purposes. These usually indicate that shafting and machinery operating at normal temperatures and moderate speeds can use mineral oils with or without a low percentage of neutral animal or vegetable oils. In general, the heavier the machine, the slower the speed and the greater the viscosity recommended. For ball bearings and chain drives a rather thick oil or grease is necessary so that it will not run off. Generally, a No. 2 grease can be used for ball bearings wherever a light or medium oil is specified, and stiffer or high-temperature greases can be substituted for heavy or extra-heavy oil. For good operation, greases must have the same temperature ranges as the oils for which they are substituted. Bearings of the babbitt and sleeve type usually operate best with oils, while greases are preferable for ball and roller bearings for normal service up to 3,600 revolutions per minute. Periodic cleaning and renewal of lubricant are essential for all types of bearings.

High-speed sleeve bearings for motors require thin lubricating oils, and if the bearings are of ample size pure mineral oils may be used to advantage, but if the bearings tend to run hot, it may be necessary to use a special lubricant that contains about 10 percent of "fixed" oil to minimize wear without increasing friction.

The quality and properties of most lubricating oils can be determined approximately without using any special testing apparatus. Impurities may be roughly detected by smearing a piece of writing paper with oil and holding it against the light; the blot will be equally transparent throughout if there are no impurities; otherwise solid particles will show. Another method is to dilute the oil with kerosene and then filter it through filter paper, which will catch any solids or impurities. To test for acids, some of the oil may be placed in a bottle and copper oxide added. If the oil retains its original color, it is free from acids, but if there are acids present the color will become greenish or bluish. Another simple test for acid is to drop some of the oil on a piece of clean bright sheet copper or sheet brass, and examine it a week later. There will be a green spot on the surface of the sheet if the oil contains acid. It is important to consult the manufacturers of the bearings of machinery if any doubt exists as to the best lubricant to use.

REPAIRING

The ginner should make preseason preparations for first-class operation, including cleaning and inspection, before he forgets the last season's troubles.

Certain operating and maintenance practices are vital from a ginner's standpoint. First among these is to have a clean gin, because it is profitable to the owner and tends to eliminate fire hazards and many mechanical troubles. At the beginning of the season and frequently thereafter the ginner should clean the plant, and it should be left clean when the last bale has left the press box.

The more important items to be checked over during the idle season are arranged here alphabetically:

Air-blast fan.
Air-blast nozzles.
Air-blast piping.
Bale boxes.
Bearings.
Belts.
Brushes.
Buildings.
Cleaners.
Clutches.
Condenser.
Conveyors.
Cotton piping.
Couplings.
Distributors.
Doffers.
Drives.
Electric grounding wires.
Elevators.
Engines.
Extractors.
Fans.
Feeders.
Fire extinguishers.
Flues.
Gears.
Greasing.
Idlers.
Lacing supplies.
Mote boards.
Motors.
Packing.
Picker rollers.
Press equipment.
Pulleys.
Pumps.
Rams.
Ribs.
Roof.
Saws.
Separators.
Telescope.
Tramper.
Trash screws.
V-belts.

An item that frequently causes trouble is the old-style distributor and its belt. Wooden gin buildings may settle or become warped. If the distributor braces are stiff arms straight to the walls, the distributor will often be pulled out of line and become a pair of snakelike boxes in which the upper box serpentines in one direction and the lower box in the reverse direction. Weight of cleaning machinery imposed upon the distributor may still further aggravate this twist and misalinement. These factors cause the paper pulleys to wear off on one part faster than elsewhere, the spikes of the belt in turn are ground off on the under side of the belts when the pulley grooves disappear, and the spikes may fall into the machinery.

Supports and fastenings of all overhead machinery should be kept tight. The cleaning screens in cleaners and extractors need checking. Screens too close to the cylinders may cause "machining" of the cotton, and, if too far away, they may cause "roping" and rolling. Extractor saws or teeth receive severe abuse from rocks, sticks, and foreign matter. These teeth should be realined and kept in good shape.

The feeding mechanism that governs the rate of feed into the stands may need adjustment, operating arms may be sprung, pinions on the "pancake" grid may be worn, or other repairs and replacements may be needed.

In the gin stands themselves, unless continual inspection is kept up, much may be overlooked. The saws must be sharpened as often as the work in any particular locality requires, which may range from once per every 100 bales to once per 400 bales per gin stand. By gumming and filing the factory pitch and the circularity of the saws must be retained as nearly as practicable. Factory pitch may be checked by using the gages or gin-saw segments furnished by the manufacturers, but if neither of these is available the leading edge of the saw tooth should be made to pass through the ribs parallel with the surface of the ribs or with the point of the tooth very slightly in advance. Unfortunately, much poor sharpening is being done in the field by persons who take no pains to maintain factory pitch or alinement or true-running saws. The best filing and gumming machines made are not automatic; it requires good horse sense to operate them and reasonable care in getting them started correctly. With either plain gummers or combined gumming and filing machines, the tooth is tapered on the sides so that the tip of the gin saw tooth is about one-half as thick as the saw disk or the base of the tooth. Department of Agriculture Circular 393, Care and Maintenance of Cotton-Gin Saws and Ribs, gives more information on the subject.

Ginning ribs may become so badly worn that seed will readily pass through the rib space or slot along with the lint and cause an undesirable addition of seed to the ginned lint. For efficient ginning, ribs should have clean, straight edges with the sharpness barely removed, and the saw slots should not vary more than 0.02 or 0.03 of an inch from the standard width. Repairs to gin ribs consist of (1) inserting new segments in a cutaway socket in the rib; (2) welding new material upon the worn spots to build up the rib, followed by grinding to correct dimension and shape; or (3) covering the worn surfaces with hardened plates of suitable width and minimum thickness to once more give well-defined edges to the ribs. Improper saw-rib relationship, which produces dragging of saws against the ribs in one or several stands of a gin plant interferes with the production of lint of uniform quality.

Defective brush cylinders or air-blast nozzles and their improper adjustments are sources of damage to the lint. If the bristles of the brush are so badly worn, or the brush is so shifted from its required relationship to the saws that effective doffing of the fibers from the saws of one or several of the stands is not obtained, some of the fibers engaged by the saw teeth will again be carried back through the outer rib and roll box, and thus cause nappy or poorly prepared lint, particularly with damp or wet cotton. Brushes should be protected from dampness, vermin,and rodents and should be refilled when necessary and then carefully balanced. Ball-bearing balancing rigs or knife-edge balances may be home-made by the ginner if he is familiar with ways and means for such work. Heavy wear of brushes sometimes occurs when they mesh too deeply into the saws. If the entire brush assemblies are badly damaged, it is advisable to have them reconditioned at the factory or a repair shop.

Effects similar to those associated with poor-condition brushes are produced if an air-blast nozzle is restricted by an accumulation of foreign matter and rust. Also, these nozzles require periodic adjustment to provide adequate doffing of the lint from the saws. Air-blast nozzles should not only be given occasional inspection to insure correct position and freedom from chokage, but should also be tested with a U-tube water gage during the operation of the gin to maintain correct doffing pressure.

The adverse effects of defective doffing mechanism are intensified by obstructions in gin and lint flues, such as rust, and joints and rivets that accumulate cotton and adversely affect the doffing action of brushes and air blasts. Therefore, these flues as well as condenser drums should be kept clean and smooth to prevent backlash, which produces undesirable effects on the quality of the cotton.

Many dividing boards in brush gins are never touched from the day they leave the factory. This board divides the saws and brushes, and it is important that its proportions be maintained. Some manufacturers provide their patrons with inexpensive metal covers for this purpose. All operators of brush gins should give this board a close inspection and guard it against change in position or wear. When the board becomes worn, it changes the volume and direction of the brush blast upon the saws, and it may seriously affect both the doffing and the moting action. Likewise, the backboard or windboard, which is above the brush at the back of the gin stand, must be kept free from wear and sufficiently close to the brush tips so that "fly" and lint do not accumulate in wads above the brush.

Picker rollers should be checked for missing spikes and should be properly alined so that the spikes center between saws.

A contributing factor to vibration is the collection of lint and fly which will build up on fan blades, thus destroying the balance of the wheel and eventually becoming a menace to life and property. The wheels, blades, bearings, clearances, and speeds of fans should be carefully inspected to reduce hazards incident to their use.

Seed elevators and conveyors of the screw or helical flight require periodic attention to insure satisfactory operation.

Press rams should be properly packed at reasonable intervals and petroleum oils should be used as the hydraulic fluid instead of water. Although such oils involve a slight expense, they prevent corrosion and protect the polished plunger surfaces and the working parts of the pump.

Gland packing on the rams or plungers of presses should be given sufficient attention to avoid break-downs and leakages.

FIRE AND SAFETY PRECAUTIONS

Fire is a continual threat to cotton gins. This necessitates inspections of fire extinguishing apparatus and electric ground wiring. Information on this subject is given in Department of Agriculture Circular 76, Fires in Cotton Gins and How to Prevent Them.

Expenditures for the care of the buildings and premises to avoid roof leaks, protect the machinery, and lessen fire hazards by frequently removing all clinging lint and dust are a good investment.

The use of sight-feed oilers on plain bearings and the exercise of care in filling oil reservoirs on other types of bearings, in addition to effecting a saving in lubricants, will minimize the hazards of fire due to surplus oil that runs onto the floor and machines. Hot boxes cause gin fires and may be avoided by adequate lubrication of bearings.

Water barrels and fire extinguishers should be kept on hand at convenient points and should be inspected frequently to see that they are in good order, barrels full of water, and extinguisher properly charged. If the fire buckets are cone-shaped they are less likely to be carried off and cannot be set down by indolent employees when combatting a fire. Sacks and buckets should be within reach of the water barrels at all times for ready use.

In gins equipped with a boiler for power or conditioning, steam-smothering pipes may be attached to the distributor and lint flue. Patented extinguishers using carbon dioxide and other gases are also available.

Safety precautions should include the education of all employees in safety-first measures; the construction of sturdy guards to protect employees from moving machinery; and the posting of conspicuous signs prohibiting any one from attempting to remove chokages on the under side of gin ribs during operation. Much loss of life and limb is annually caused by saw cylinders catching the clothing or arms of employees when attempting to get under a gin stand while it is running. The wisdom of other precautions, such as preventing smoking, carrying of matches, and the keeping of an adequate force of labor on hand to meet fire emergencies is obvious. Cotton-house fires are common, and the same protection should be arranged for them as for the gin building.

If there is any likelihood of a fire existing within a cotton bale, it should be placed at once on the open lot at a safe distance from all buildings, wagons, and other cotton. Constant vigilance is the best precaution against fires, and clean premises will generally prevent fires caused by spontaneous combustion or carelessness.

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f FIELD PEAS

FARMERS' BULLETIN No.1803
U.S. DEPARTMENT OF AGRICULTURE

FIELD PEAS can be grown throughout the greater part of the United States. They are used extensively in the Cotton Belt of the Southeastern States as a winter cover crop and in the Pacific Northwest as a seed crop. They are also used for hay, pasturage, and silage. A cool season is essential for their best development.

Cultural requirements are not exacting, but in practically all regions inoculation is essential or beneficial.

Clay loams of limestone formation or neutral or low-acidity soils are best suited to the crop.

The use of fertilizer in the North is not recommended. In the Cotton Belt of the southeastern United States at least 200 pounds of superphosphate or 300 pounds of basic slag per acre should be used.

The Austrian Winter field pea is the most satisfactory variety for use as a winter cover crop in the South. In northern latitudes, where spring planting is practiced, a number of varieties may be used.

Cuttings for hay should not be made until the pods are well formed, and it is not well to harvest for grain until the pods are turning yellow, or later when the harvesting is done with a combine.

Pasturing with sheep and hogs is profitable in some regions.

When field peas are grown for hay, mixtures with oats or barley are recommended. In regions where the pea weevil is prevalent, seed should be fumigated promptly after being threshed.

This bulletin is a revision of and supersedes Farmers' Bulletin 690, The Field Pea as a Forage Crop

Washington, D. C. **Issued June 1938**

CULTURE AND PESTS OF FIELD PEAS

By ROLAND McKEE, *senior agronomist,* and H. A. SCHOTH, *agronomist, Division of Forage Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

THE COMMON NAME "field pea" as used herein refers to varieties of peas (*Pisum arvense* L.) used for seed, forage, cover, and green manure. For the most part they are round, smooth seed which may be solid brown, yellow, bluish green, or mottled brown or gray. The plants are annual and have slender succulent stems 2 to 4 feet long, which ascend with support (fig. 1).

While the early colonists grew field peas in a limited way their extensive use was a much later development. At present they are grown for forage and seed more or less in New York, Michigan, Wisconsin, Minnesota, eastern North Dakota, and South Dakota, Montana, Idaho, Oregon, and Washington, and for a cover crop and green manure in the southeastern part of the Cotton Belt and in the Pacific Northwest.

CLIMATIC REQUIREMENTS

A cool growing season is necessary for the field pea, as high temperatures are much more injurious than frosts and are most disastrous when they occur when the pods are setting. These climatic requirements limit its successful production as a summer crop to the Northern States and Canada. It may, however, be grown as a winter crop in the Southern States (fig. 2). Its moisture requirements are less exacting than its temperature requirements, but, other things being equal, it does best where the rainfall is fairly abundant. A 15-inch rainfall in the northern Great Plains is sufficient to produce a good crop, while 20 inches of rain in Kansas, Nebraska, or Colorado are inadequate.

When grown for hay or green manure, field peas are more tolerant of high temperatures than when grown for a seed crop. Profitable seed production is confined to northern latitudes or regions with comparatively cool weather.

USES

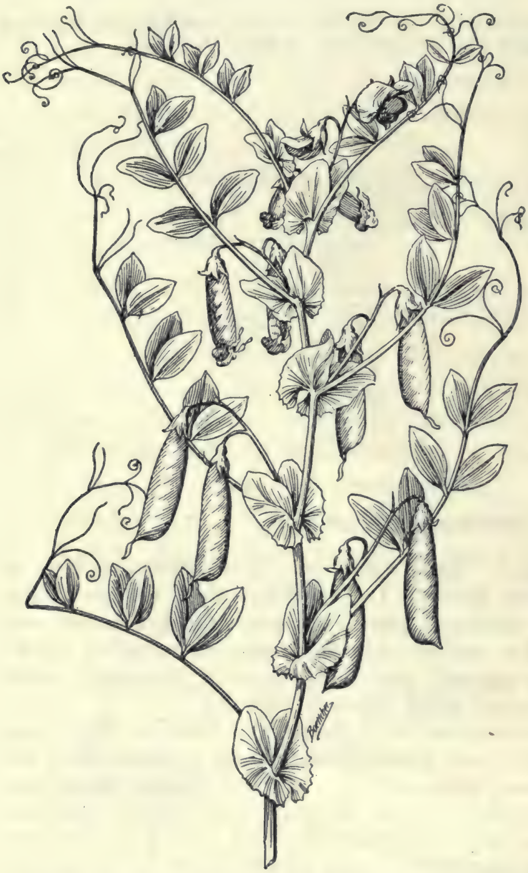

FIGURE 1.—Fruiting branch of a field pea vine, showing the characteristics of stem and leaf and the succession of bloom and pods.

Field peas are grown for hay, silage, pasture, green manure, and seed. When grown for hay, they are usually mixed with oats or some other small grain (fig. 3). These mixtures with grain stand up much better and make harvesting easier. The presence of rye, oats, or barley in the crop also causes it to cure more quickly. When grown for hay, the field pea works into a rotation very nicely, because it is removed from the field early in the year, thus allowing ample time for a thorough preparation of the soil during the fall. The feeding value of field pea hay is about the same as that of alfalfa.

Field peas make good silage when grown in mixture with a small grain and cut when the grain is nearly mature. Such silage has a high feeding value and has given excellent results when used for fattening cattle and sheep.

While field peas are not utilized as green manure or as a cover crop in some of the regions in which they are grown, thousands of acres are planted for these purposes in the Cotton Belt. As the field pea is a legume, it adds nitrogen to the soil as well as organic matter.

Because field peas should not be trampled, they are a success as a pasture plant only when planted with a small grain or when allowed to mature so that the entire plant may be utilized as pasturage. Their use in this latter manner is a common practice in parts of the Rocky Mountain States, where they usually are grazed by sheep.

COMMERCIAL VARIETIES IN THE UNITED STATES

The varieties used in any region depend upon adaptation and the object for which the crop is grown. In the Southern States, where fall planting is practiced, winter hardiness is essential, and the Austrian Winter variety is used almost exclusively. In Colorado, the French Gray, Canadian Beauty, Clamart, and Agnes are all recommended for seed production, and Canadian Beauty and Agnes are recommended for pasture and hay. In the Great Lakes States, Canadian Beauty, Multipliers, Marrowfat, Scotch, Chang, and Chancellor varieties are recommended. In the Pacific Northwest the Austrian Winter, Bluebell, and Alaska are most commonly grown. Austrian Winter and French Gray have dark-colored seed, usually a gray ground overlain with purplish or brown dots or blotches.

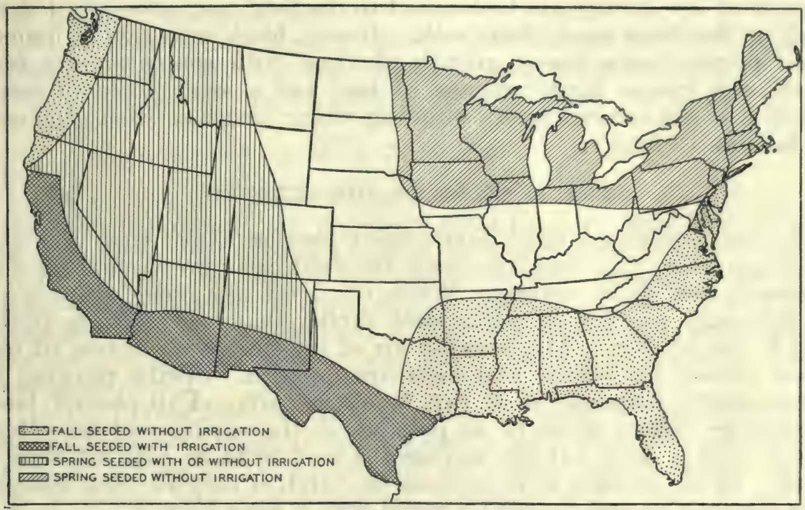
FALL SEEDED WITHOUT IRRIGATION
FALL SEEDED WITH IRRIGATION
SPRING SEEDED WITH OR WITHOUT IRRIGATION
SPRING SEEDED WITHOUT IRRIGATION

FIGURE 2.—Outline map of the United States, showing areas to which the field pea is well adapted.

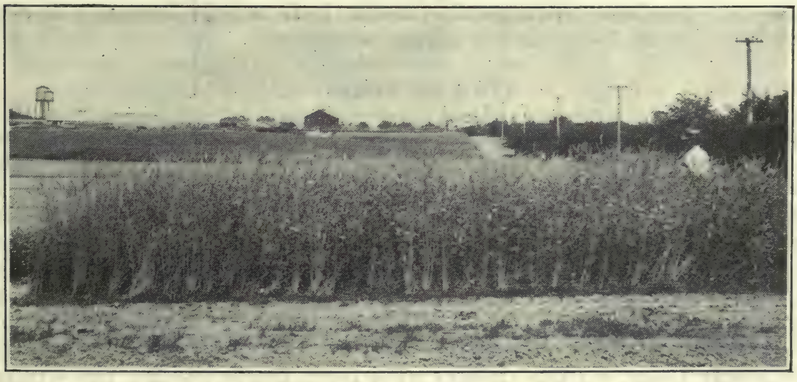

FIGURE 3.—Mixture of Austrian Winter field peas and rye on the Arlington Experiment Farm, Arlington, Va., near Washington, D. C., sown October 10, photographed June 14. The green-weight yield was 8.75 tons per acre.

Other varieties mentioned are lighter in color and for the most part are a cream yellow. The Austrian Winter matures later than the French Gray.

SOIL AND MOISTURE REQUIREMENTS

Well-drained clay loams of limestone origin or soils that are neutral or of low acidity are best suited to the field pea, although it does well on fertilized sandy loam soils. Heavy, black soils rich in humus tend to produce a heavy growth of vines with comparatively few pods and give a large tonnage of hay and a small yield of seed. They will not succeed where standing water occurs or where the soil is habitually boggy.

PREPARATION OF THE SEEDBED

In the northern United States most growers claim that it is advantageous to fall-plow the land for field peas on account of the necessity for early seeding. When the land has been fall-plowed, it is usually possible to sow a week earlier than when spring plowing is the practice. The opening up of the soil to the action of the frost during the winter also improves its tilth. Spring plowing is satisfactory, however, if it can be done early. Fall-plowed land should be disked as early as possible in the spring and smoothed down with a drag harrow in case the seed is to be planted with a drill. If the seeding is to be done by hand, it may be done following the disking and the seed covered with a drag harrow.

In the Southern States the largest acreage of winter legumes follows cotton, in which case little or no preparation of the soil is necessary. Other crops, such as tobacco, peanuts, cowpeas, soybeans, and melons, leave the soil in good condition, and but little preparation of a seedbed is essential following these crops. If for any reason the land needs plowing, the preparation is more expensive and requires more time. On clay soils where weed growth is abundant or where the soil is packed hard, plowing or heavy disking is essential.

In the Pacific Northwest the soil usually is quite compact where a fall-seeded crop has been grown, and will therefore require plowing. A medium-heavy disking just before seeding is sufficient for land that has been spring-cultivated. Late winter or early spring plowing is most desirable for spring seedings.

TIME OF SEEDING

In the North field peas must be planted early enough in the spring to set pods before the warm weather of summer arrives. The young plants are not harmed by light frosts, and even as far north as southern Canada and the northern part of Michigan, Wisconsin, and Minnesota the seed can be planted during the latter part of April and early May. In the intermountain sections of Colorado, Wyoming, Montana, Idaho, and the eastern parts of Oregon and Washington, from the first to the middle of April is the most favorable time. Throughout the Southern and Pacific Coast States in localities where there is little danger of a hard freeze during the winter, field peas should be seeded from September 15 to October 15.

In the northern part of the Cotton Belt, seeding should be done, if possible, during the last half of September, and in the southern part, early in October. Seedings made as late as the first of December will usually winter-kill severely or make but little growth by the time the crop should be turned down for corn or cotton.

In western Oregon and western Washington, fall seedings should be made from September 15 to November 1. Seedings after November 1 may be winter-killed.

In intermediate latitudes, where hard freezes may be expected during the winter, farmers sometimes sow field peas in February, thus giving them time to mature in May before the advent of hot weather.

RATE OF SEEDING

The size of the seed and the abundance of the rainfall govern the rate of seeding. In northern latitudes with abundant rainfall or irrigation, small-seeded varieties, such as Golden Vine or Austrian Winter, should be sown at the rate of 60 to 90 pounds to the acre; large-seeded varieties require nearly twice this amount. Under drier conditions, the quantity of seed should be decreased to 45 to 60 pounds for the small-seeded varieties and 80 to 100 pounds for larger-seeded varieties.

In the Cotton Belt, where the Austrian Winter is the variety commonly used, 40 pounds of seed an acre is recommended. When field peas are sown with grain in regions of ample rainfall, equal amounts by weight of field peas and grain should be used. In drier regions the amount of grain should be decreased. Mixtures with grain, however, are of doubtful value in regions of light rainfall.

METHOD OF SEEDING

The field pea is best sown with a grain drill, and if either a hoe drill or a disk drill is available it should be used in preference to broadcasting the seed by hand. In the South, where field peas are planted in cotton middles, the three-row one-horse drill is used. Usually the middle hole of the drill is closed, as the crop does not grow well in the center of the row, where the middle is low. In any drill care must be used to see that the feed in the drill does not crack the seed. Where a grain drill is not available, field peas may be sown broadcast and covered with a disk, spike-tooth harrow, or cultivator. Seeding in double rows is frequently practiced in the dry-land portions of the Pacific Coast States. This is accomplished most successfully by using an ordinary grain drill in which part of the holes or feeds have been closed. To allow for easy cultivation two open holes should alternate with four closed ones, so that each pair of rows will be 30 inches from the next pair.

Field peas should be planted 2 to 4 inches deep. In clay loam a depth of 2 inches is best, while in sandy soil a deeper covering is preferable.

When field peas are seeded with grain, the common practice is to mix them and sow them in one operation.

GERMINATION OF SEED

Seed more than 2 years old is liable to have low germination. Good seed of the current season's crop should germinate 90 percent or more, as field peas have little or no hard seed. In purchasing seed the grower should endeavor to obtain seed of the current season's crop that is accompanied by analysis tags showing the purity and germination of the seed. It is well to have the statements (tests) given on the tags confirmed by a reliable seed laboratory before the seed is planted.

FERTILIZERS

The use of fertilizers with field peas is not to be recommended in most regions of the northern United States. In the Cotton Belt of the Southeast the use of fertilizers is often essential. Of the common fertilizer constituents, phosphoric acid is usually the most needed. The fertilizer should be applied in the fall just prior to or at the time of seeding, in quantities varying with soil and cropping conditions. When the summer crop preceding the field peas is heavily fertilized, the peas will need little, if any, fertilizer. If the soil is poor and the summer application of fertilizer is light, the use of 200 to 400 pounds of superphosphate, or 300 to 600 of basic slag, and 50 pounds of sodium nitrate or ammonium sulphate or an equivalent nitrate fertilizer is advisable.

In the Pacific Northwest applying land plaster or gypsum at the rate of 50 to 100 pounds an acre in early March on fall-planted field peas and at the time of seeding on spring plantings increases yields on most soils. On soils high in fertility land plaster is not generally necessary.

INOCULATION

For best results, field peas must be inoculated. This is especially true in the more recently developed farming districts of the western United States and in the Cotton Belt of the Southeast, where the soils usually do not contain the necessary inoculating bacteria. Inoculation can be accomplished by the use of commercially available pure cultures, directions for which will be found on the package, or by the use of soil from a field that has recently grown field peas.

When soil is used, a small amount can be mixed with the seed at the time it is sown, or a larger amount can be applied broadcast and worked into the soil before the seed is sown. Many farmers in the South think it desirable to use both the commercial culture and soil.

The use of commercial fertilizer seems to favor inoculation and helps to insure nodule formation. The fertilizer, however, unless it is basic slag, should not come in contact with inoculated seed, as it may injure the inoculating organism.

Barnyard manure is effective in inducing inoculation, and its use, when available, is recommended.

WINTER-KILLING

None of the field pea varieties are hardy in the colder areas of the northern part of the United States. The most winter-hardy varieties, such as Grey Winter and Austrian Winter, are usually hardy as far north as Washington, D. C., in the East, and central Oklahoma in the Great Plains. For this reason the Austrian Winter has become the popular variety for planting as a winter cover crop in the Southern States. Other varieties winter-kill regularly in any part of the Cotton Belt.

In western Oregon and western Washington, hardy varieties seldom suffer winter injury, and in many years medium-hardy varieties survive satisfactorily.

TURNING UNDER FOR GREEN MANURE

When used as a green manure to precede annual crops field peas should be turned under about 2 weeks before the planting of the annual crop. In the South, where field peas are used most largely for this purpose, earlier plowing is advised if the field peas have made sufficient growth. When the weight of green field peas is 14 pounds per 10- by 10-foot square, the nitrogen in the crop, calculated on an acre basis, is equivalent to about 300 pounds of nitrate of soda and is sufficient for a good crop of corn. To delay turning after this growth is attained in order to get 50 to 100 percent more nitrogen means running risks of dry weather, of unwieldy growth, of greater difficulties in getting stands of corn, and of possible injury from vetch worms. In their zeal to get the maximum quantity of nitrogen many farmers wait too long and run into unforeseen difficulties.

When the peas are at the stage of growth mentioned, they can be turned under with an ordinary two-horse plow with a 12-inch rolling colter attached.

If the growth is heavy, a thorough disking previous to plowing under will make the plowing easier. It also prevents a layer of coarse organic matter being deposited between the furrow slice and furrow bottom, which at times seriously retards the movement of soil moisture.

PASTURING FIELD PEAS

When field peas are planted for pasturage, either alone or with small grain, they give best results when allowed to mature before the animals are turned in, so the entire plant may be utilized. This is the common practice in parts of the Rocky Mountain States where such pastures are usually grazed by sheep. Animals pasturing on field peas should be confined by movable fences to one portion of the field at a time. If sheep or hogs are allowed to roam over the entire field, much of the crop is wasted. Lambs will fatten on field pea pasture in from 70 to 90 days, and a good crop will usually fatten from 10 to 15 lambs per acre, each animal gaining about 8 pounds a month. Hogs in a thrifty condition will fatten in from 60 to 90 days, and, if not obliged to gather their food over too large an acreage, will make an average daily gain of 1 pound, according to investigations at the Wyoming Agricultural Experiment Station.

More rapid gains may be made by hogs when a limited quantity of corn or barley and a supplementary protein of tankage, alfalfa meal, or skim milk are fed in addition to the peas. Access to a mineral mixture also should be provided.

In the Pacific Northwest fall-sown field peas are often pastured in early spring, usually by sheep. Pasturing begins about March 15 and continues to April 20 or May 1. This reduces forage production, but many believe it increases seed setting and reduces harvesting costs because there is less material to be handled. Such pasturing should not be done when the land is so wet that puddling will result. Pasturing too late in a dry season may reduce yields of both forage and seed.

In pasturing hogs and sheep, it is well to remember that good results cannot be expected unless feed is abundant. The only way to assure continued substantial gains is to move the fattening animals to a new field as soon as peas become scarce and to use stock animals for cleaning up the field. Pasturing is a wasteful method of harvesting a crop, even under favorable conditions, and when the weather is adverse it not only prevents the animals from feeding properly, causing loss of flesh, but also adds heavily to the direct loss of the crop itself. A combination of pasture and dry feed gives the best results.

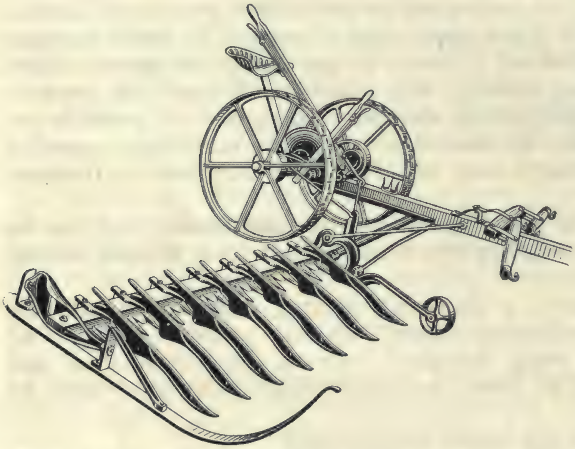

FIGURE 4.—A mower, showing an attachment designed to raise the field pea vines off the ground and allow the passage of the cutter bar beneath them.

HARVESTING FOR HAY

The proper time to cut field peas for hay is when most of the pods are well formed. When they have been seeded with grain, the time of cutting may be governed partly by the maturity of the grain, but the varieties of field peas and grain should be so chosen that the crop can be harvested at the most favorable period of maturity for both. Formerly, a crop of field peas was considered difficult to harvest, and much of the harvesting was done with a scythe or an old-fashioned cradle. There are now available for the ordinary mower attachments consisting of guards that extend in front of the cutter bar and lift the vines off the ground and a windrow attachment which effectively removes the vines from the swath and leaves them in a windrow behind the mower (figs. 4 and 5). The hay can be left in the windrow or bunched with a rake and left until dry and ready to stack or put into the mow.

Hay yields of field peas alone or in mixture with grain range from 1 to 3 tons per acre, depending on soil and other factors.

HARVESTING FOR SEED

The field pea should be cut for seed when the pods are mature and the seed is firm. It is not well, however, to wait until the vine and pods are both dry, since if that is done the loss from shattering and weevil damage is sure to be large. Field peas are most commonly cut for seed with an ordinary mower equipped with a bunching attachment, but the windrow attachment previously described (p. 8 and fig. 5) is also used with good results. When the bunching attachment is used, a man with a pitchfork follows the mower and moves the bunches out of the path of the horses on the succeeding round. This method leaves field peas in a better condition to be hauled to the threshing machine or stack than when they are merely windrowed; it also prevents, to a large degree, the shattering which would accompany any use of a hay rake. When growth is heavy, the windrower is probably more satisfactory than the buncher. In a great many cases field peas are threshed directly from the bunches or windrows. If rain occurs while field peas are being cured, they should be turned as soon as the top of the bunch is dry. If this is neglected, considerable loss of seed by shattering will result.

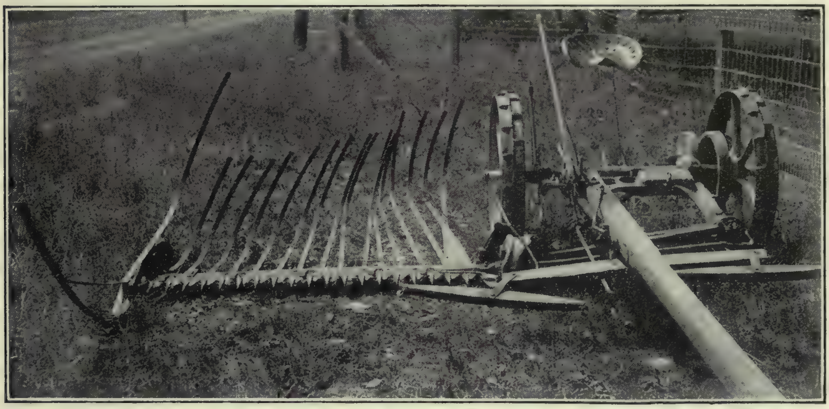

FIGURE 5.—A mower with a windrow attachment which automatically removes the material from the swath.

Yields as high as 2,000 pounds per acre or more are sometimes obtained, but an average yield is more nearly 1,000 pounds per acre.

THRESHING

The threshing of field peas is usually done with an ordinary grain separator (fig. 6) or combine fitted especially for the purpose by the substitution of blank concaves so that only one row of concave teeth is left below the cylinder. Usually four concave teeth are sufficient to retard the passage of the vines long enough for the cylinder to break the pods and release the seeds (fig. 7). By thus limiting the number of concave teeth and reducing the speed of the cylinder to about 600 revolutions per minute it is possible to thresh field peas without cracking any considerable percentage of the seeds. In regions of large field pea production, the threshing machine or combine is commonly equipped with an adjustable wooden pulley which makes it possible to decrease the speed of the cylinder to the required number of revolutions. Where the field peas are intended wholly for livestock feeding such precautions are not necessary since cracked seed is then not objectionable, but there may be some waste by loss of small portions of the seeds. Where the crop is to be sold for seed purposes, great care should be used in threshing, as cracked, chipped, or partly hulled seed is less viable and has low market value. A small pea huller, of which there are several kinds on the market, is well adapted to the uses of the farmer who is growing only a small acreage and expects to sell his threshed crop to a seed dealer. Where a machine of this kind or a grain thresher or combine is not available, the farmer can thresh seed for his own use with a flail or by treading out the seed with horses, as shown in figure 8. After the seed is flailed or tramped out, considerable work is required to separate the seed from the trash, so that this becomes in the end a rather expensive method of threshing. Combines are now in rather common use for threshing field peas. The field peas are picked up, and attachments are used in handling the crop from the swaths or windrows.

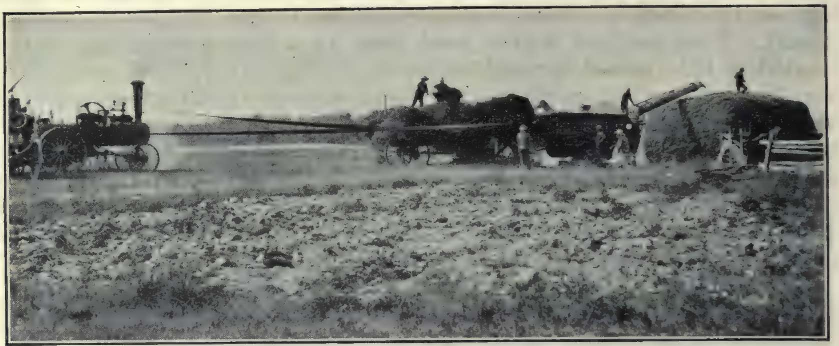
FIGURE 6.—Threshing field peas with an ordinary steam threshing outfit equipped with a self-feeder.

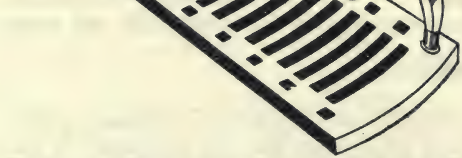
FIGURE 7.—Concave plates, with all but four teeth removed, adjusted for threshing field peas.

PREPARATION OF SEED FOR MARKET

Field peas for market should be reasonably true to variety and should be cleaned so as to comply with one of the grades in the official United States standards. Copies of these standards may be obtained from the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C.

Cleaning may be done with a number of mechanical cleaners, of which there are several on the market. These cleaners can be adjusted not only to satisfactorily clean but also to grade the seeds to size. For convenience in handling, the seed is usually put in 100-pound strong burlap bags.

Fumigation is necessary in regions where the pea weevil is a factor. The fumigating should be done immediately after threshing for best results (p. 14).

Seed should be stored under dry, well-ventilated, rodent-free conditions.

SOURCE OF SEED

Although field pea seed can be produced throughout the northern United States wherever there is ample rainfall, most of the acreage planted for this purpose is in Oregon, Washington, and Idaho. In recent years the increased use of the Austrian Winter variety for a cover crop in the South, where seed production has not proved practical, has resulted in greatly increased acreage in the Pacific Northwest, where conditions are especially favorable for seed production.

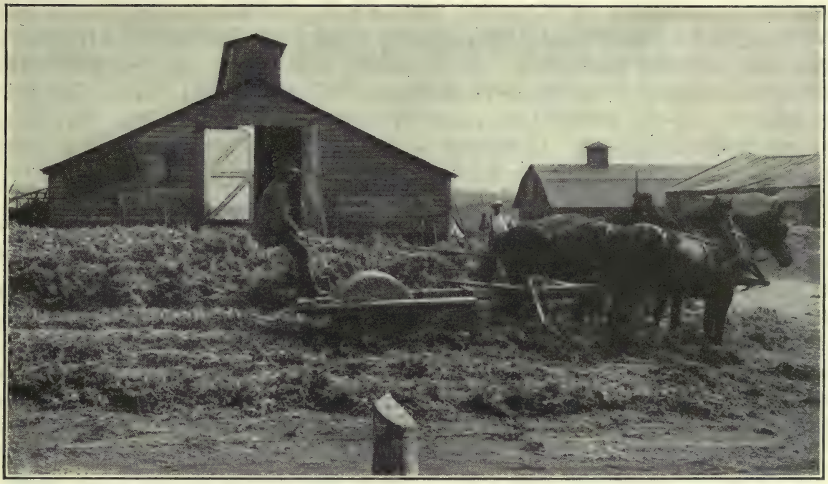

FIGURE 8.—Treading out field peas with horses and a concrete roller. Few peas are cracked by this method of threshing.

Some seed of the Austrian Winter variety is imported from south-central Europe. Seed of the Partridge variety is occasionally imported from New Zealand. Seed of other varieties in small quantities is sometimes brought in but is unimportant. Judging from limited experimental results, there seems to be no difference between imported and domestic-grown seed, nor has any difference been noted between seed produced from spring and fall seedings.

ROTATIONS

The value of field peas in rotations with hay, grain, and corn has been proved throughout the Northern States and also in a few localities in the mountain districts and irrigated valleys of the West. In the Northeastern and North Central States, where rotations are regularly practiced, field peas usually follow a meadow crop. Field peas have been found very effective in furthering the disintegration of the sod, and this fact has determined their position in the rotation.

The substitution of field peas for summer fallow in the wheat rotations of the Pacific Northwest is being practiced by some growers. A crop of field peas leaves the ground in practically as good a condition for wheat as fallow, and gives equally good yields. Also smut in the wheat is less noticeable where wheat follows field peas. At the Sherman County Branch Experiment Station, Moro, Oreg., the average yield of four plots of spring wheat after field peas for 4 years was 40.2 bushels an acre, while the average yield of two adjacent plots of wheat after summer fallow during the same period was 38.5 bushels to the acre.

DISEASES[1]

LEAF SPOT AND STEM BLIGHT

Leaf spot and stem blight (*Ascochyta pisi* Lib., *Mycosphaerella pinodes* (Berk. and Blox.) Stone, and *Ascochyta pinodella* Jones) are fungus diseases which occur in most pea-growing sections and may become destructive in the more humid areas. They are characterized by brown to black spots of varying sizes and shapes on all aboveground parts of the plant. A characteristic blackening of the stem, often extending from a short distance below the soil surface to several inches up the stem, is common in some localities. Many stems may be girdled and killed. Disease-free seed should be sown and rotation practiced. Satisfactory control will probably not be possible until resistant varieties or selections are available.

BACTERIAL BLIGHT

Bacterial blight of peas, caused by *Phytomonas pisi* (Sack.) Bergey et al., attacks all above-ground parts of the plant, producing olive-green to olive-brown, water-soaked areas. The entire infected plant may be killed. No really satisfactory control measures are known, but where practical, only clean seed should be sown, and rotation should be practiced.

LEAF BLOTCH

The fungus *Septoria pisi* West. causing leaf blotch, kills areas of the leaf, and may run into the petioles and stems. Usually the spots appear at the margin of the leaf as yellowish areas which gradually darken and enlarge. The entire leaf and petiole may be killed and brownish dead areas may be produced on the stems. Occasionally a field of peas may be injured severely, but generally the disease is not important. Rotation should help to hold it in check.

POWDERY MILDEW

Powdery mildew is a disease caused by the fungus *Erysiphe polygoni* DC. and is characterized by a white coating on the leaves, stems, and pods. Usually it is most destructive on late-planted or late-maturing varieties of field peas. Rotation and clean cultivation are desirable when practical. Where only small portions of a field are affected, the spread of the disease can be retarded by dusting with a mixture of 4 parts of sulphur to 6 parts of hydrated lime. The number of applications necessary varies with conditions. If large areas are affected it is not economical to dust.

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[1] A more detailed discussion of these diseases will be found in Farmers' Bulletin 1735, Pea Diseases and their Control.

DOWNY MILDEW

Downy mildew, caused by *Peronospora viciae* (Berk.) DBy., is widespread but seldom very destructive except in certain humid areas. The fungus causes localized light-green spots often blotched with brown on the upper surfaces of the leaves. In the later stages of the disease the affected areas die and turn brown. On the lower surface of the leaf the affected spots are covered with a whitish moldy appearing growth. The disease is carried in the seed and lives in the soil for an indefinite period. Rotation should be practiced, and, if practical, seed should be obtained from semiarid regions.

ANTHRACNOSE

The fungus *Colletotrichum pisi* Pat. which causes anthracnose attacks all above-ground parts of the plant. On the leaves the spots are irregular in outline and brownish in color, with somewhat darker borders. The affected areas on the pods are circular and sunken, and on the stems they are elongate. Anthracnose is seldom of much importance, and no control measures have been worked out. Crop rotation should be helpful.

FUSARIUM WILT

Fusarium wilt, caused by the fungus *Fusarium orthoceras* Appel and Wr. var. *pisi* Linford, is characterized by a rapid wilting of the vines without conspicuous rotting of the roots. Rotation of peas with other crops is recommended.

ROOT ROTS

The term "root rots" is applied to a number of diseases caused by different fungi, all of which attack the underground parts of the plant, causing more or less decay. The decayed tissue may be reddish, gray, brown, or black. As a result of the death of the roots the tops are stunted and often yellowish, and the plant may die. Rotation is recommended as a good practice, but it will be only partly successful as a control measure since some of the root rot fungi attack other crops as well as peas.

MOSAIC

Field peas, as well as other legumes, are affected by mosaic disease. The presence of these diseases is recognized by the intermixing of light- and dark-green areas in the leaves. The mottled areas are irregular in outline and may follow the small veinlets. No control is known.

INSECT ENEMIES

PEA WEEVIL

The pea weevil (*Bruchus pisorum* L.)[2] is the most serious insect enemy of the field pea, and has done more than anything else to limit the acreage of the crop. It is a small grayish or brownish-gray beetle, marked with lighter spots. The insect lays its egg on the young pod; the egg hatches and produces a larva which bores through the wall of the pod and enters the young seed, where it feeds on the growing embryo and later pupates. The pupa may remain in the seed until the next season, emerging the following spring, but many of them come out soon after harvest, so that the dates of emergence will range from harvest to planting time the following year.

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[2] Described in U. S. Department of Agriculture Yearbook for 1898, pp. 233–260.

The most effective method for preventing damage to the seed harvested is to fumigate with carbon disulphide as soon as the seed is threshed. Carbon disulphide can be obtained at a reasonable cost from any druggist. The seed must be placed in a tight container and exposed from 30 to 48 hours to the fumes of this liquid. The carbon disulphide should be exposed in a shallow dish placed on top of the seed, since the vapor is heavier than air. *This vapor when mixed with air is inflammable, and, to avoid a serious explosion, care should be taken not to ignite it in any way.* One pound of the liquid is usually sufficient to fumigate 100 bushels of seed, but it is well to use somewhat more than this in order to kill all of the insects. Chloropicrin and hydrocyanic acid gases are occasionally used as fumigants. Prompt fumigation after threshing is essential.

Continuous cropping to the field pea is almost sure to mean a constant increase of the pea weevil. Practically the only remedy is to stop growing field peas for several years. Control measures such as burning the stubble and destroying shattered seed before weevils emerge will help materially. More detailed information can be obtained from State experiment stations or from the Bureau of Entomology and Plant Quarantine, Department of Agriculture, Washington, D. C.

PEA APHID

The pea aphid or plant louse (*Illinoia pisi* Kalt.) is another insect which occasionally does considerable damage. It has appeared in field pea sections at intervals and practically destroyed the season's crop, but it does not stay with the crop so continuously year after year as does the weevil. The aphid increases rapidly during a period of warm, dry weather, but a heavy rain, even when the insect is abundant, will sometimes free the vines almost entirely from it. Parasites and predators, under favorable weather conditions, often hold the infestations of this pest in check. Dusting with an insecticide has in some instances been found practical with canning peas, but the returns from field peas hardly justify the expense. Information regarding such practice can be obtained from State experiment stations or the Bureau of Entomology and Plant Quarantine, Department of Agriculture.

PEA MOTH

The pea moth (*Laspeyresia nigricana* Steph.) is found in the Great Lakes region and the Pacific Northwest.[3] The moth appears soon after the field pea vines begin to bloom, usually about July 14, and lays its eggs on the pods, leaves, and stems. The eggs hatch in

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[3] For further information see Wisconsin Agricultural Experiment Station Bulletin 130, The Pea Moth: How To Control It, and Washington Agricultural Experiment Station Bulletin 327, The Pea Moth.

7 to 10 days and the larvae enter the pods and feed on the seeds. Growth is completed in from 16 to 26 days, then they emerge from the pods and pass the winter in the soil.

The most effective remedy is to grow early varieties, seed early, thresh early, and then burn the rubbish left on the field, or plow it under deeply, preferably in the fall. Whenever possible, new crops should be planted at a distance of at least 2 miles from fields that were known to be infested during the previous season.

NEMATODE INJURY

The field pea is subject to attack by a nematode which causes the so-called root knot on the roots. Most damage is done during comparatively warm weather and under such conditions serious damage may be done. In the Southern States where damage is most likely and where field peas are used for green manure, this can be avoided by late planting in the fall and turning under comparatively early in the spring. Rotation with nonsusceptible crops and growing the crop only during the coolest part of the year will help control this pest.

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COMMUNITY BUILDINGS FOR FARM FAMILIES

U.S. DEPARTMENT OF
AGRICULTURE

FARMERS' BULLETIN No. 1804

COMMUNITY BUILDINGS have been built by a few rural communities to house the activities of their organizations. Some communities have rooms in stores or in school buildings; occasionally they have a borrowed building. But many have no space at all. A country community particularly needs a community building, for families are more scattered there than in a city, and it needs organizations and planned meetings for social and recreational purposes and for the discussion of community affairs.

The purpose of this bulletin is to acquaint rural communities that need these buildings with successful building programs in other places, so they may profit by the experiences of others. Each community must define its own needs before it builds, but knowing about the financing, the cost, and the planning of other buildings will be helpful. The type and design of a structure, room sizes, room uses, materials, and equipment, may suggest new arrangements, new uses, and economies.

Because the community building houses the activities of the people, it becomes a definite part of the community plan, for the location and lay-out of school buildings and churches, the location of the services that people need in everyday life, the parks, and the roads, affect both the location and the uses of a community house. If there is already satisfactory space for some of the activities, it is uneconomical to plan additional space. Duplication is costly and reveals a lack of planning. Planning for one activity always means taking into consideration the others.

A recent trend in community-building planning is the many-use building that is designed for business, civic, social, recreational, and sometimes educational activities—all under one roof. Such an arrangement has many advantages. There are more contacts between groups. There is economy in using rooms and equipment for many purposes. More people have an interest in the building. It can become the outstanding building in the community in beauty of design and in its multitude of uses.

The value of the community building is greater than the housing of a community's activities. From the very beginning, the problems of its financing, its planning, its construction become the people's project and bring many groups together, working for the same purpose—for the good of a community.

This bulletin supersedes Farmers' Bulletin 1173, Plans of Rural Community Buildings. It brings together the experience of recent projects in the development of community-building programs.

Washington, D. C. **Issued September 1938**

COMMUNITY BUILDINGS FOR FARM FAMILIES

By Blanche Halbert, *Collaborator, Bureau of Agricultural Economics, and Economic Analyst, Farm Security Administration*

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THE COMMUNITY BUILDING IS PART OF THE COMMUNITY PLAN

A COMMUNITY is built to live in. Some communities are good living places, for the people in them plan them as such. A well-planned community is designed for all the needs of all the people and for the future as well as the present. Usually, community planning is continuous planning, for conditions change and people move. The activities that go on within a community—the business and civic, the educational, the social and recreational—are so closely interwoven that planning for one activity means planning for others.

If a new school building is to be built, its gymnasium or auditorium, its library, its clubroom and kitchen, if these are included, and even its classrooms may be used for many outside community activities. A church may also be planned for some of these same uses. A new community building may duplicate the work of these other buildings.

The parks, the roads, and the location of the services that people need in every-day life help to determine the locations of community buildings and some of their uses. To be conveniently located, any new public building must fit into the general scheme of planning.

The community building—the meeting place for many of the activities of the people—is a definite part of community planning that should be considered along with it. In some small communities the community building has become the center of all social and recreational and many business activities—the actual hub of the wheel. Like the community, it should be planned for the future. Usually, people gather together for business and social reasons. They want to carry on their business better. They like friendly visiting. They want to have a good time. Although in many places community houses are built for a single use, the community building is becoming more and more a place with many uses (fig. 1), flexible enough to meet the needs of changing modes of life.

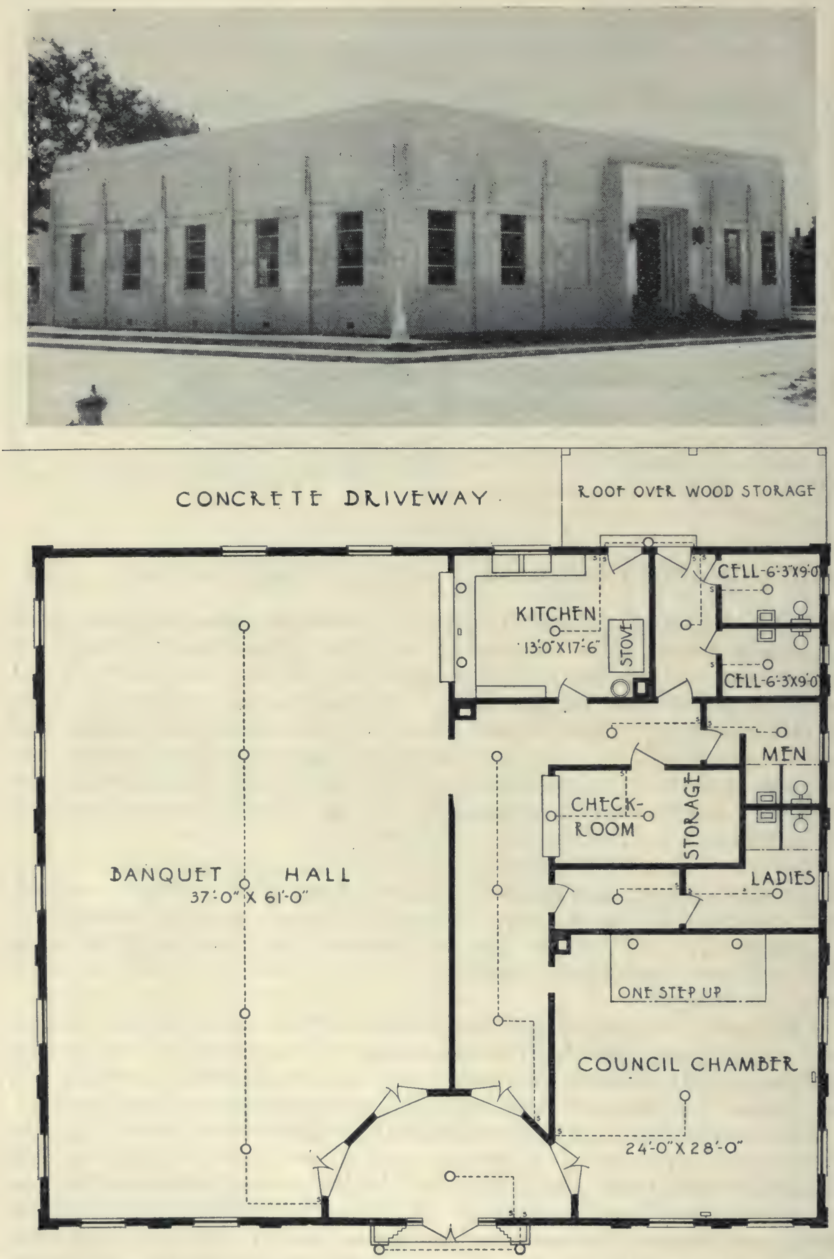

CONCRETE DRIVEWAY
ROOF OVER WOOD STORAGE
KITCHEN
13'-0"X17'-6"
STOVE
CELL-6'-3"X9'-0"
CELL-6'-3"X9'-0"
MEN
CHECK-ROOM
STORAGE
LADIES
BANQUET HALL
37'-0" X 61'-0"
ONE STEP UP
COUNCIL CHAMBER
24'-0"X28'-0"

FIGURE 1.—The Stanwood, Wash., community hall that serves a town of 700 people and a large agricultural community is an example of a many-use building featuring a town council room. The assembly hall with stage is designed for meetings, theatricals, and other social uses. This building, which cost about $18,000, was financed by the people of Stanwood and the Works Progress Administration.

A community that establishes a community house has the responsibility of building for the satisfaction and pleasure of its own community, but it should also build one that is good enough to be imitated; for communities very often reproduce the buildings seen in other localities. Although all the details of the plan may not serve a second neighborhood, a faulty plan and ugly design will not serve adequately any neighborhood.

NEW WAYS OF LIFE AFFECT THE LOCATION AND USES OF A COMMUNITY BUILDING

New trends and new ways of life in country neighborhoods are demanding new locations and new uses for community buildings. Automobiles and hard-surface roads have made neighborhoods larger. Neighborhood boundary lines have broken down, have been pushed outward. Many an old neighborhood with its county crossroads and surrounding open country now includes the nearest village or the one where most of the services are obtained. These once open-country neighborhoods have become farm-family and village-family neighborhoods. In these places new and easy travel has changed the location of the community building from the open country to the village. It has increased the activities that go on within it, for village and farm community organizations have many common interests.

Other changes are going on in many country neighborhoods. Kinship ties are not as responsible for neighborhood boundary lines as they once were. There are fewer church-parish neighborhoods now, although they still exist in some places. The township does not determine the neighborhood to the extent that it did in the past.

Many neighborhoods are now determined by trade locations, particularly if this trade location contains the school. In the more thickly populated areas the tendency is toward the village and open-country neighborhood. When the density of farm population increases—when families move into a community—social conditions change, and the community center takes on new activities.

These new trends in neighborhood sizes are important considerations in planning for the location and use of community buildings, for when a building is once located and built it usually remains for a long time.

WHEN SHOULD A NEIGHBORHOOD BUILD A COMMUNITY BUILDING?

Each community must decide for itself when it needs a community building and the advantages this building will bring. There are always problems of changing conditions, of people moving, of the breaking down of organizations. There are no established rules that will help a neighborhood to decide whether a community building will be continuously and successfully used after it is built.

But community buildings are used chiefly by organizations, and such trends in organizations as the following will affect the success of the enterprise: (1) The longer a club is organized the more likely it is to continue or to have some other organization take its place. (2) There are more clubs and organizations in densely populated rural communities than in others. (3) Organizations are more stable when they have a diversity of activities. (4) They last longer when they have competent leaders. (5) They continue for a longer period when they are not in large towns.

The many-use building—the one designed for a number of organizations—has a better chance for success if it is well arranged (fig. 2) than the one used for one or two activities, for if one organization fails there are others to continue.

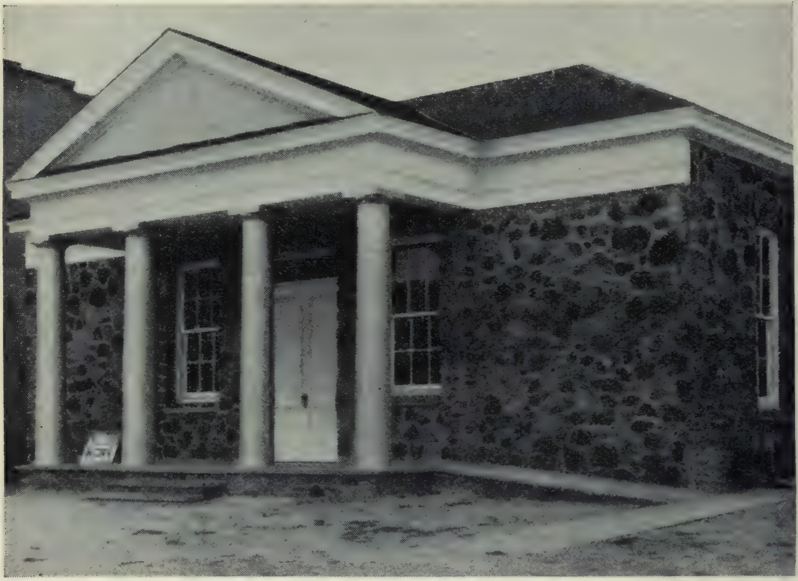


FIGURE 2.—The community center at Warm Springs, Ga., is an example of a many-use building of attractive architectural design achieved with stone construction. This building cost about $12,000. It includes a large auditorium with stage, a kitchen, the library, the city clerk's office, and a club room.

SOME COMMUNITY BUILDINGS ARE UNSATISFACTORY

Many buildings have been abandoned or have been taken over for activities for which they were not designed. The chief reasons for these failures were: (1) A definite lack of leadership in the community, (2) too many factions in the community, (3) difficulties over the control of the building—particularly when buildings are managed by the older members of a community and new members wish to take part in the activities, (4) disagreement over uses of the building, and (5) unsuccessful planning.

In one community a new $15,000 building was recently constructed and given to the community by a civic-minded citizen. Because of factions, it is used very little. Here is an example of the consequences of poor organization work.

Another community reports a $185,000 building which was a gift to a small community with less than 1,000 people. This building, according to the report, is not successful, because it is controlled by the "wrong people" for the best use. The report continues:

> It is practically a white elephant in the hands of the community, and is always in the red. Under the present set-up it is not used sufficiently. . . . If we were to remodel it I would suggest that it be made more suitable for the needs of the people and be administered by strong organizations that would have some use for it and would have an interest in seeing that the building was used and kept up. At the present time anyone who uses the building pays a fee for its use. It is not used very much, and these fees do not meet the cost of maintenance.

In another small place, a community center had been in operation for 15 years. When the public-school auditorium and gymnasium were built, these seemed to serve the purpose better than the space in the community center, part of which was later turned over to the school for a library. The auditorium in the center is still rented for public functions.

It is important that community buildings be made adaptable for many activities, as they must often be put to unexpected uses. For instance, one building that was designed chiefly for home-bureau meetings and 4-H Club work was used for the Union Sunday School at one time, at another time for music classes, on different occasions for dancing schools, and it has met other needs.

Community buildings seem to be unsatisfactory partly because of failure to plan for all the present uses of the building and for probable future needs. But the dissatisfaction may also be due in part to unsuccessful organization and administration.

One neighborhood that built a community house in 1933 discovered in less than 2 years that the building was too small. Now an addition is being considered. If the original plan is such that this addition can be inexpensively and easily made without interfering with the convenience of the plan or unity of the design, the remodeling will probably be satisfactory. But many buildings are not so planned as to lend themselves readily to remodeling.

In some fairly new buildings no arrangement has been made for food service—adequate kitchen and dining space. After a few months such facilities have been considered essential, and adding them has cost more than if they had been included in the beginning.

In a sparsely settled locality a community building that has been operating for about 10 years includes an auditorium 32 by 40 feet but no stage. As the building cost but $2,450, this omission may have been considered an economy. Now the auditorium needs to be considerably enlarged, and a stage is desirable.

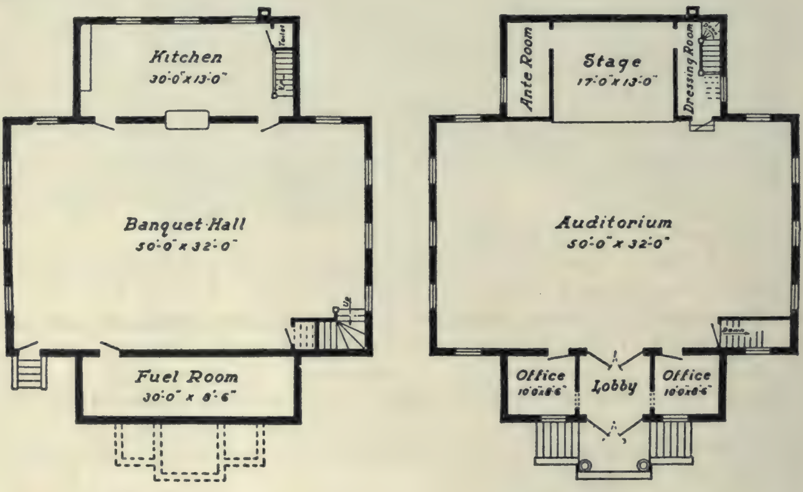
In another community where a building costing more than $100,000 was erected, heat was provided for in only part of the space. Heating for the rest of the building is to be added later at unusual expense.

In some instances it is not easy to foresee future uses and future additions, and remodeling is unexpected. For instance, a community house in a Southern State was planned as an outgrowth of a community church. Shortly after the building was completed a folk-school program was developed that required considerable space. The work of this folk school is believed to be so vital that major remodeling, or the erection of an entirely new building, appears necessary.

A few community buildings have been abandoned or bought by individuals for commercial purposes. Others have been donated to schools or used for other public activities.

On the other hand, many community buildings that have been used for 25 or 30 years are reported to be satisfactory for present-day needs. A community house built in Wilder, Vt., in 1899, is reported still satisfactory in plan. Except for having poor acoustics, it seems to meet present-day requirements. Wilder is a town of about 1,100 people, and the building is used by the Grange, social clubs, 4–H clubs, and home-demonstration groups. It has a library, space for social functions, bowling alleys, pool tables, and a swimming pool. The auditorium and the library are on the first floor. There is space for other activities in the basement which is the ground floor. This building cost $12,000 when built, and the financing was accomplished through individual donations. This is a special type of building which might not serve every community unless other buildings were available for other group activities.

The community house at Como, Wis., a township building erected in 1917 and located 5 miles from a town, is reported to be satisfactory for present use. With the exception of a new furnace, redecoration of the basement, and painting, no improvements have been made since it was built. This building is used chiefly by farmers' organizations (fig. 3).



BASEMENT PLAN **FIRST FLOOR PLAN**

FIGURE 3.—Plans of the community building at Como, Wis. This building, erected 20 years ago, is reported as meeting satisfactorily present needs.

BUILDING USES

Before a community plans a building it will need to know the purposes for which it is to be used. These uses will differ in each community, for the number and types of organizations differ, and the number of satisfactory rooms or buildings in existence that are already in use for community purposes will affect the functions of the new building. In some small places community buildings are planned to provide for almost all the social, recreational, civic, and some of the business activities of the community. In many other places such buildings are designed mainly for some special group purpose but are frequently used by other groups and for other purposes. The most common of these special groups which have their own buildings are schools, libraries, churches, Granges, 4–H Clubs, home-demonstration clubs, and home bureaus.

THE MANY-USE BUILDING

Community buildings designed for many purposes, providing for a number of activities under one roof, are increasing in number. Many communities seem to prefer a single building for many activities to small buildings or rooms. It is more economical also to build one large building than a number of small ones. There is a saving in auditorium and stage space, in kitchen and dining space, in heating, plumbing, and much of the service space; for several groups may use the same spaces and services. There is a saving in construction of the roof and the foundation as well as in the building site. In most instances the structure is a better one than any one of a number of separate buildings would be.

The many-purpose building brings a number of groups together. It can be made the most serviceable and outstanding building in the whole community. It can be an example of good architectural design, attractive placement, and convenience. Native materials can be used attractively, and they are usually cheaper than others (fig. 4). As the building is used by most of the people, it becomes the people's building. Each community, however, must decide for itself the activities that it can house under one roof.

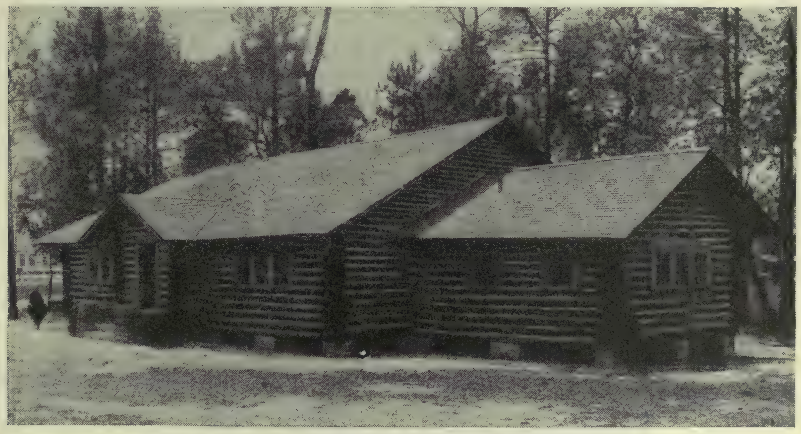


FIGURE 4.—The many-use community building in Calhoun County, Fla. With log construction and pier foundation, costs need not be high.

Pittsville, Wis., a community of 500 people, has a large surrounding farm population. A many-use community building has just been built there that provides a meeting place for the city council and the space needed for records, a suitable stage and rooms for dramatics, a motion-picture projection booth, rooms for discussion purposes, space for athletics and social functions of various types, and

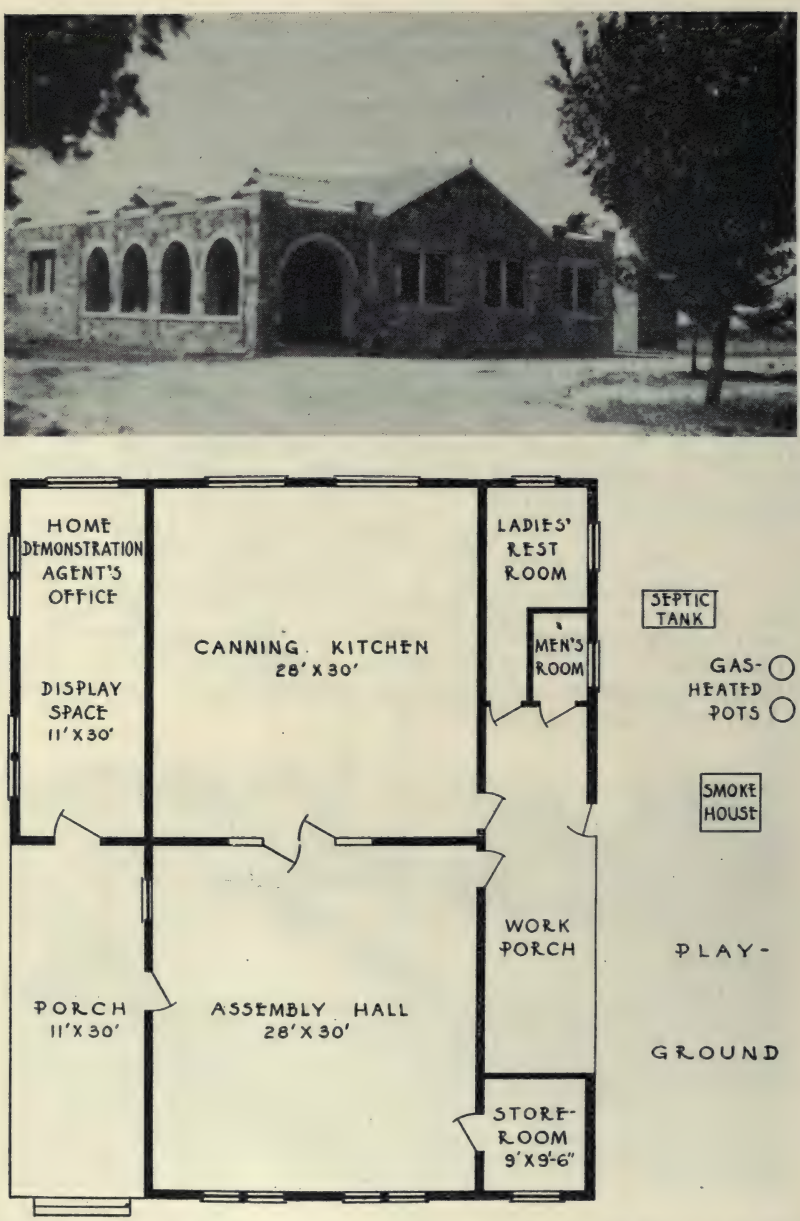

HOME DEMONSTRATION AGENT'S OFFICE
DISPLAY SPACE 11'X30'
CANNING KITCHEN 28'X30'
LADIES' REST ROOM
MEN'S ROOM
SEPTIC TANK
GAS-HEATED POTS
SMOKE HOUSE
PORCH 11'X30'
ASSEMBLY HALL 28'X30'
WORK PORCH
STORE-ROOM 9'X9'-6"
PLAY-GROUND

FIGURE 5.—The Fort Stockton community building, Pecos County, Tex., was built of local stone at a cost of $10,000. The site was donated. Office space for the home demonstration agent, the assembly hall, the canning kitchen, work porch, and storage room provide generous work areas and space for social activities. On the grounds are the smokehouse and gas-heated pots for soap making and lard rendering. Space is set aside for a 5-acre playground.

rest rooms. It is used both for high-school athletics and for the adults in the community. Space and equipment for serving food were unfortunately omitted. This building of brick and hollow tile with overall dimensions 55 by 115 feet cost about $30,000.

Stanwood, Wash., a little town located in the heart of an agricultural district, has recently built a town hall–community building. This was the dream of a civic-minded mayor and the result of many years of planning. In this attractive building, an example of excellent architectural design, is the city council room, to be used also for social functions, as well as the large assembly room. In a back corner is the city jail. The combination of business and social activities housed in a well-designed, well-located building can make it of first importance in the community, and its many uses may well justify its cost (fig. 1).

Other types of country communities combine other activities for the many-use building. At Fort Stockton, Pecos County, Tex., a community building has been designed to serve as a meeting place for country people and for a work center. It is owned and controlled by the county court, but it is under the supervision of the county home demonstration agent. This building is most successful as a community center and meeting place for farm men and women. The county agent says the building is complete in every respect and no additions are necessary (fig. 5).

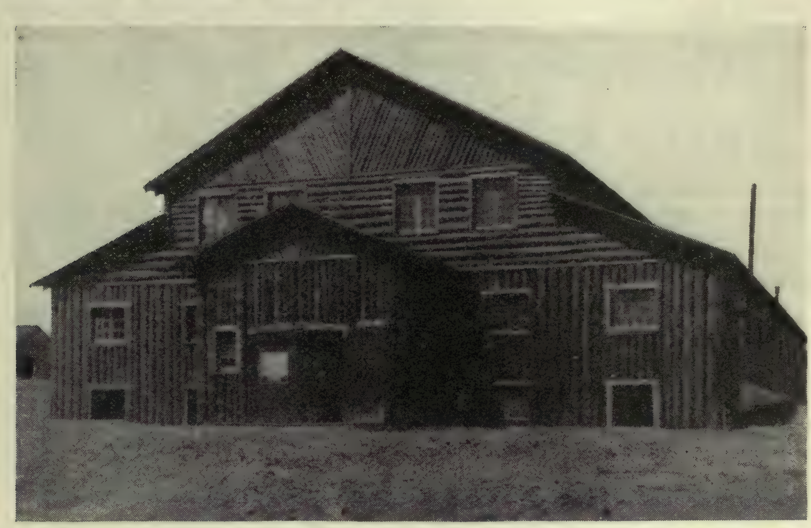


FIGURE 6.—The community building at Rose City, Mich., is a good example of the perpendicular use of cedar logs.

Some of the many-use buildings in small towns have under one roof the village board room, space for the justice court, the public library, and clubrooms for recreational and social activities. Such a building was recently built in Ellsworth, Wis., a town of about 1,100 people. This building was completed only 4 years ago, but its space is now reported to be insufficient.

In Rose City, Mich., a little town of 338 people, an attractive cedar-log community house designed for many uses has just been completed. This building provides for farm meetings, home-economics groups, athletics, dramatics, moving pictures, and many social functions. It has a city council room, a library, an auditorium 48 by 72 feet, and a stage. A dining room 30 by 48 feet and an adjoining kitchen, provide for food service for the many groups (fig. 6).

It is not always necessary to build large, costly structures for many-use buildings, because many inexpensive ones, and sometimes very small ones, can be successful.

Darlington, Fla., is a small village in a farming country. Here a community house was built in 1935 for only $1,500. The lot and some of the materials were donated. A great many activities have been provided for with this small amount of money. This simply designed log house is used by the women's clubs, the boys' and the girls' 4-H Clubs, the health clinic, and for community sings, prayer meetings, a great many social activities, and even for weddings. The county agent says: "It fills all the needs of the community."

The Whiteside community house, in Lincoln County, Mo., a little log house in a community of 200 people, was sponsored by a club of only 10 members. This building serves as a meeting place for the town board, civic groups, church and school organizations, the home economics club and for community sings, holiday festivities, and other social meetings. It has a library that is open 2 days each week. The cash outlay was only $205 with but $85 for materials and $120 for labor. Other materials and labor, valued at about $200, were donated.

Replies from a group of rural leaders in Illinois (Illinois Agricultural Experiment Station, Circular 470, Rural Community Buildings) suggest that community buildings in that State are used or are needed for—

> social functions, extension work, plays and entertainments, recreation and athletics, demonstrations, church functions, exhibits, community fairs, carnivals, and part-time adult education classes. They may contain reading rooms and libraries, nursery rooms, and hospital units. They may be used for mass meetings and elections and may contain office rooms for town officers.

A many-purpose building takes on new uses as a community changes, and new activities take a leading part in community affairs. The radio, for instance, has greatly increased the use of the community building by young people. The use of such buildings for drama, music, and hobbies has been increasing, and in the many-use building a wide variety of educational, social, and recreational activities goes on.

THE SPECIAL-USE BUILDING

Many communities do not have multiple-use buildings. If they have any at all that can be used for community activities, they are usually those designed for special groups such as schools, churches, Granges, libraries, 4-H Clubs, typical social clubs, and home demonstration clubs.

THE SCHOOL BUILDING FOR COMMUNITY USE

School buildings are used more for community purposes than other buildings, for school districts often determine neighborhood boundary lines. These buildings are built mainly for the education of children, but sometimes rooms in them are entirely suitable for other community uses. In many open-country neighborhoods school buildings are the only places to which people can go for activities, but open-country schoolhouses often are too small for these purposes.

Occasionally, a rural community is able to include a room or two for community use in the school building when it is planned, but this is only possible when a building is to be erected. In other places community rooms have been added later. These are usually financed by the people of the community and not through taxation. School buildings that have auditoriums with stage equipment or gymnasiums are commonly used for community purposes without interference with school work, but these are few in small communities.

In Williamsville, Sangamon County, Ill., a school and community building was built, with an auditorium, a community room with a seating capacity of 150, a kitchen, and the necessary classrooms. This community room was furnished by the local club, and no charge is made to any community group for its use. The auditorium, which seats 1,500, is used by the school for basketball and social functions, and by the community for the meetings of women's clubs, the farm bureau, 4–H Clubs, and other organizations. This building cost about $93,000. It is controlled by the board of directors of the high school. (Illinois Station Circular 470, Rural Community Buildings.)

Some elementary school buildings are used for community purposes, particularly those that have rooms with stage equipment, and are large enough for community gatherings.

A large number of school gymnasiums with community-building arrangements have been built during the last few years. This trend appears in both small and large communities.

When Peshtigo, Wis., a town of 1,500 people, decided to build a gymnasium for its school the entire community became interested in this piece of work. As a result, the gymnasium that was originally planned for the school was finally also planned for community use, and it is now being used by many organizations. The gymnasium with its stage equipment and adjoining kitchen service, provides for athletics, dramatics, and many types of social functions. The building is controlled by the school board (fig. 7).

In many townships where there are no community buildings, the school building, even though very small, serves as a community center. In one school district where a small new schoolhouse was about to be built, its plan was revised at the suggestion of the organizations in the community to include a clubroom 24 by 32 feet, and a kitchen in the basement. This new room is satisfactory for both school and community use.

A new trend in school-building use seems to point toward a need for the planning of school buildings for many of the community activities, and planning for all the people—young and old—with the building used to its full capacity.

The Farm Security Administration that designed a number of combination schools and community buildings has considered this trend in its school-community building planning.

The Westmoreland Homesteads, a 250-family project, located 8 miles from Greensburg, Pa., is planned for immediate as well as for future development (fig. 8). Here an auditorium seating 500, adjoins the school building. This is to be used both by school children and adults. A home economics room with a well-equipped kitchen in the school building is to be used for community social functions. Nearby is the athletic field that is also for community use. The Westmore-

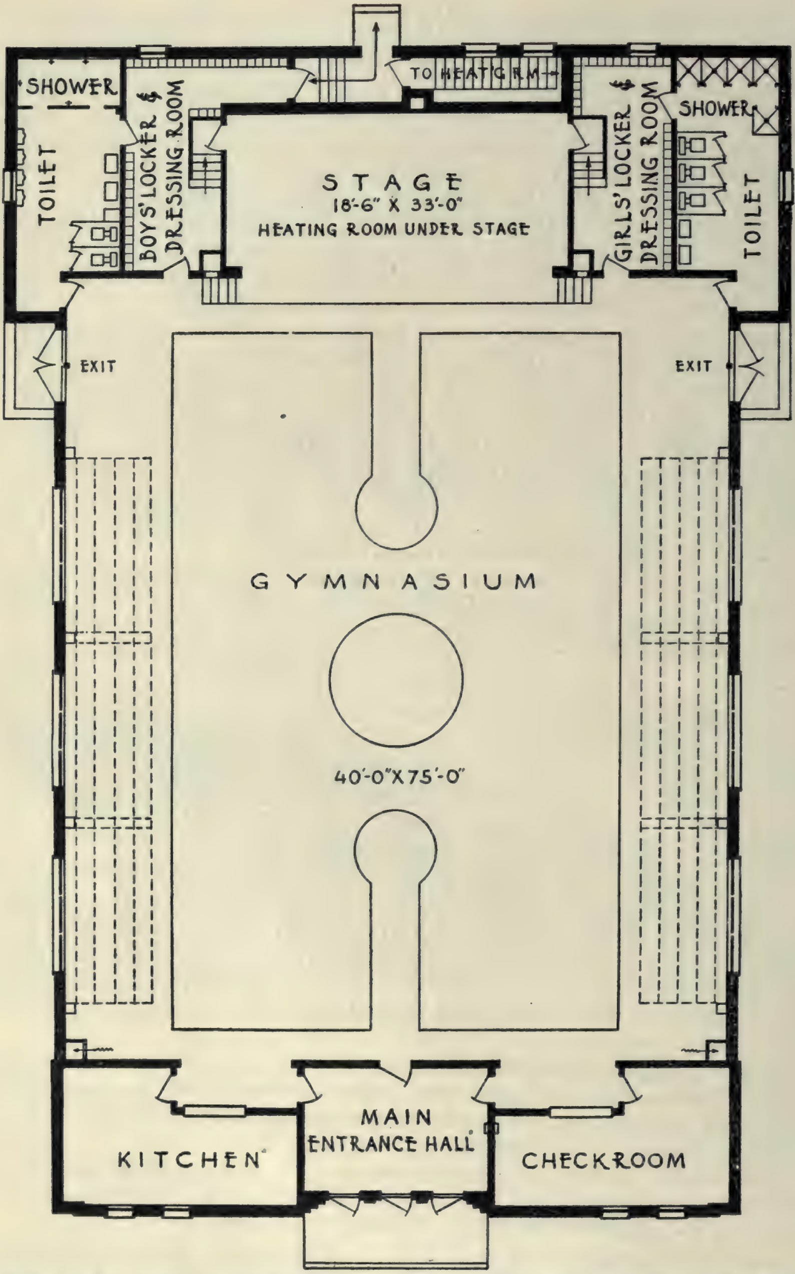

SHOWER
TOILET
BOYS' LOCKER & DRESSING ROOM
TO HEAT'G RM
STAGE
18'-6" X 33'-0"
HEATING ROOM UNDER STAGE
GIRLS' LOCKER & DRESSING ROOM
SHOWER
TOILET
EXIT
EXIT
GYMNASIUM
40'-0"X75'-0"
KITCHEN
MAIN ENTRANCE HALL
CHECKROOM

FIGURE 7.—Floor plan of the building at Peshtigo, Wis., showing gymnasium, auditorium, and kitchen. This one-story cinder-block building with concrete floor was built for $19,800, heating, plumbing, wiring, and fixtures included.

land Homesteads are so laid out that there is plenty of ground for new buildings as they are needed, and all the main buildings are planned with future additions in mind.

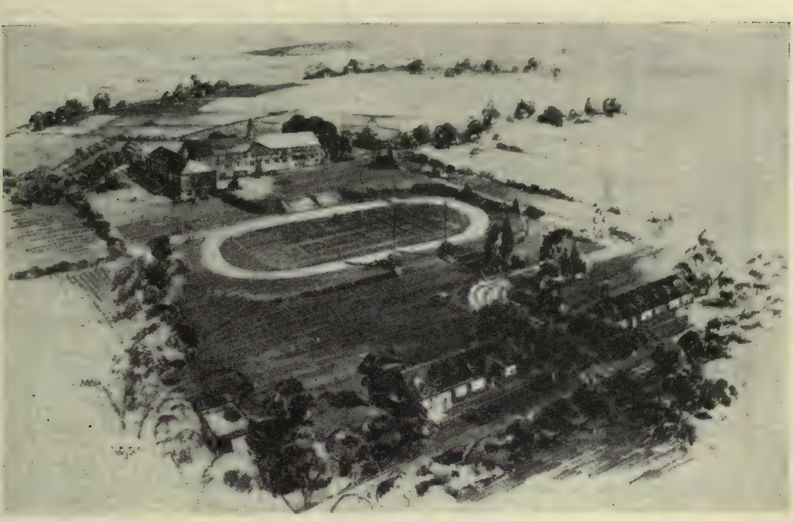


FIGURE 8.—Lay-out of the Westmoreland Homesteads, Greensburg, Pa., showing the school building in the background, with the auditorium at its left. In the right foreground is the general store, and at the left, a building for future business use. (By courtesy of the Special Plans Division, Farm Security Administration.)

At the Duluth Homesteads, located 7 miles from Duluth, Minn., a community center school building has also been designed. Here the community building is to be connected with the school building by a small library that can be entered through either building. The auditorium building has a large clubroom and kitchen. As at Westmoreland Homesteads, an athletic field is a part of the lay-out (figs. 9 and 10).

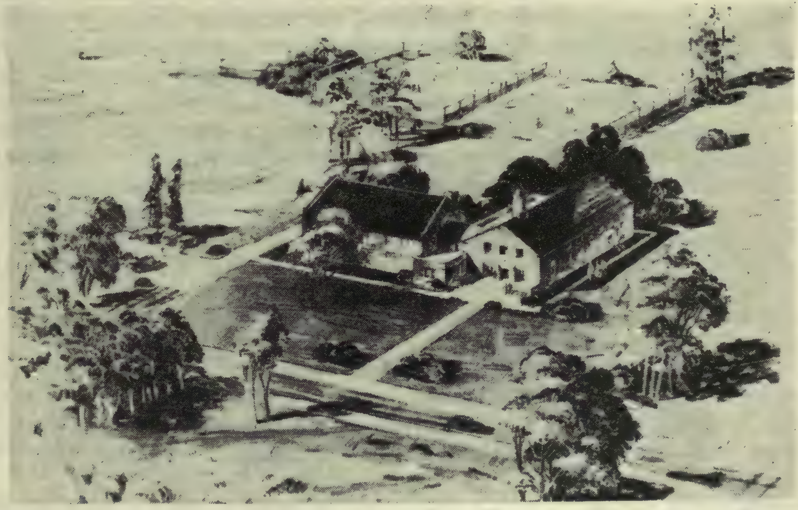


FIGURE 9.—Community-center lay-out, Duluth Homesteads, Duluth, Minn. The community building, at the right is connected with the school building, at left by a small library. (By courtesy of Special Plans Division, Farm Security Administration.)

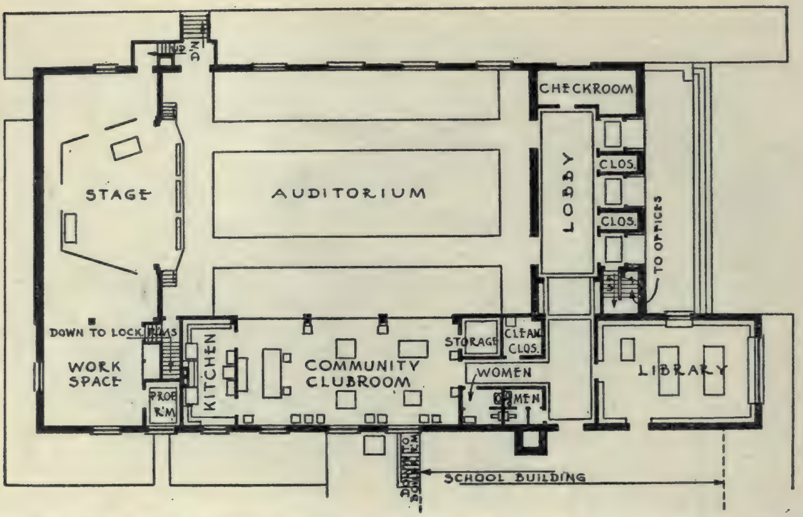


FIGURE 10.—The plan for the community building at Duluth Homesteads with clubroom and kitchen convenient for the use of both the school and the community. The library, located between the two buildings, can be easily reached from either building. (See fig. 9.)

The Newport News Homesteads, near Newport News, Va., built for 200 Negro families, has a school and community building. This is a T-shape building with the auditorium built from the center. It is so planned that new space may be easily added by building rear wings from the ends of the school building, but the courts are to be kept open.

Plum Bayou Homesteads, in Jefferson County, Ark., is a Farm Security Administration cotton-farming community planned for about 100 families. The farms are 40 acres each, and the whole tract covers about 5,000 acres. Its proposed lay-out is based on the expectation of extensive use of school buildings by all the people in the community; a number of the buildings are designed for use by both children and adults.

Some of the school buildings are also designed for community use. The shop, for instance, is planned for both student instruction and farm repair. The grade school has an auditorium and library for all the people. The high-school building is also to be used by adults. The lay-out includes a health center.

The homemaking and social-center building has many uses, and both women and school children can have every convenience and advice in homemaking and school projects. This building also has space for a nursery (fig. 11).

The shop, another double-purpose building, also planned and equipped for school and community, contains a wood shop, a metal shop, a finishing room, and a large assembly room. Farmers who use these rooms and tools may receive instruction in making farm repairs and improvements.

Whenever an entire community can be built from the ground up, as has been possible in the Farm Security Administration communities, new types of community planning following the trends of organizations and activities can be set up. The planning of school buildings for community use is one of the most conspicuous trends.

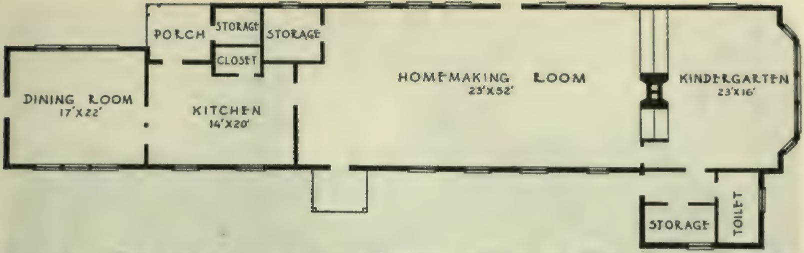


FIGURE 11.—The homemaking and social-center building at Plum Bayou Homesteads, Jefferson County, Ark. The building is planned for adults and children of all ages. The homemaking room is to be used as a homemaking school laboratory and as a place where the women of the community may obtain assistance in home projects. The kitchen is large enough for instruction and the serving of large social groups. It has the usual cabinet and sink arrangement as has also the homemaking room. Its location between the dining room and the homemaking room permits convenient service in both rooms. The hinged wall tables keep the room space free for many uses. The work porch is equipped with laundry tray and washing machine.

CHURCHES AS COMMUNITY BUILDINGS

Before communities thought very much about community buildings, meetings were held in whatever places were available—usually in homes, school buildings, and churches. As neighborhoods became larger and as organizations increased in size and number, more space was needed.

Most country churches are small and not very suitable for community activities; but in some places church organizations are large, and space has been planned for these meetings. Some of these churches serve as the only community building in the neighborhood.

The Shannondale Community House at Gladden, Mo., was designed mainly for religious and social uses; it is an outgrowth of community-church activities. Located on a high ridge in the Ozark Mountains, it is built of local stone. It was financed mainly by the Church Extension Board of the Evangelical Synod of North America, but some of the labor was donated by local people. Some funds were also supplied by the local church and interested persons.

Here community-church services are held on Sundays, and during the week groups that are interested in music, drama, hand work and weaving, and discussion hold their meetings. The folk school that meets in this building draws men and women from several counties. As the religious program is well adapted to the needs of the countryside, the minister has living quarters here.

The Shannondale Community House (fig. 12) appears to be a place where religious, educational, and social activities are closely related.

Another well-known type of church and community-building arrangement is that of the Latter Day Saints, commonly found in Utah. These buildings are frequently designed with a chapel that is used entirely for church purposes, and with a separate auditorium or amusement hall adjoining. There are several hundred of these chapel-community buildings in Utah. Rooms for church auxiliaries, Sunday-school classes, food service, and some of the community organizations are commonly included. The Latter Day Saints' church and community building is an outgrowth of the community work of the church that has been in progress for a long time. The chapel at Cedar City (fig. 13) serves about 1,100 members. It is used

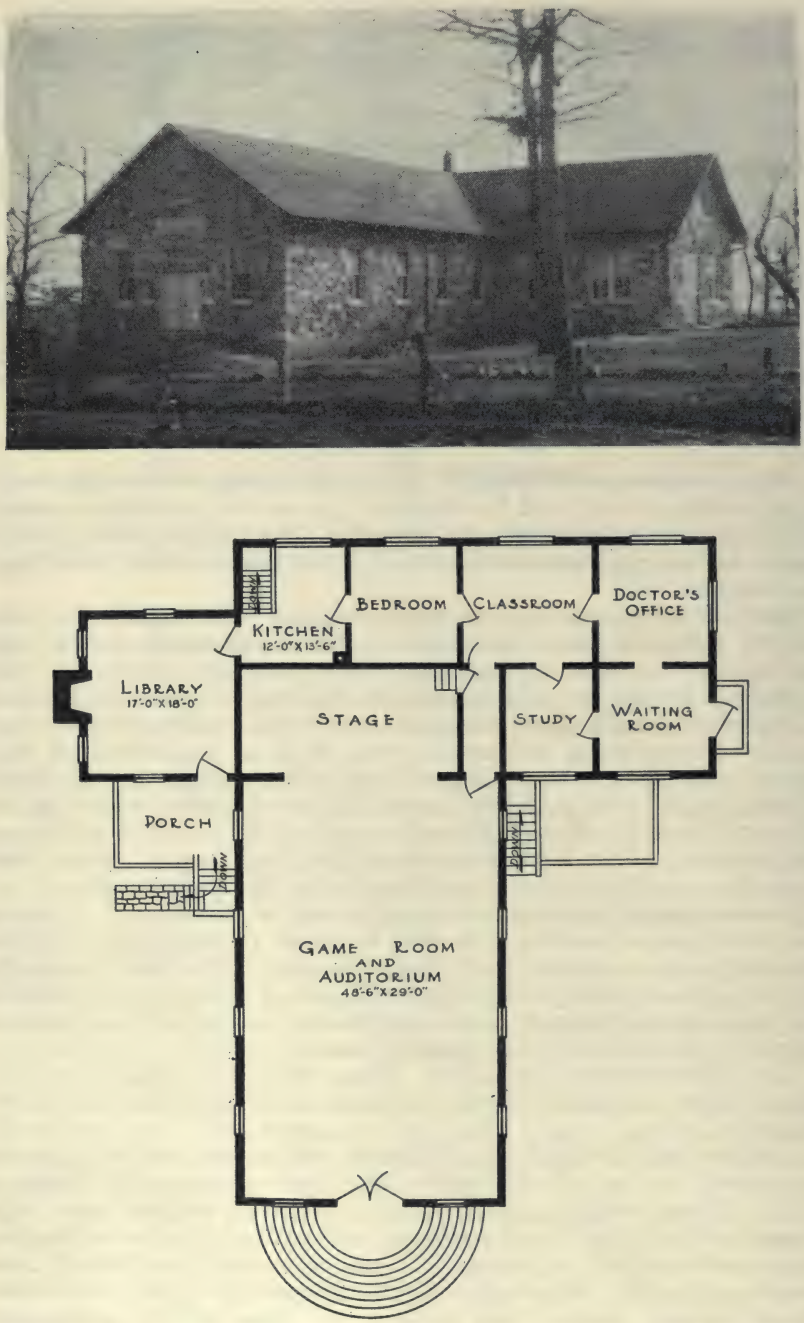
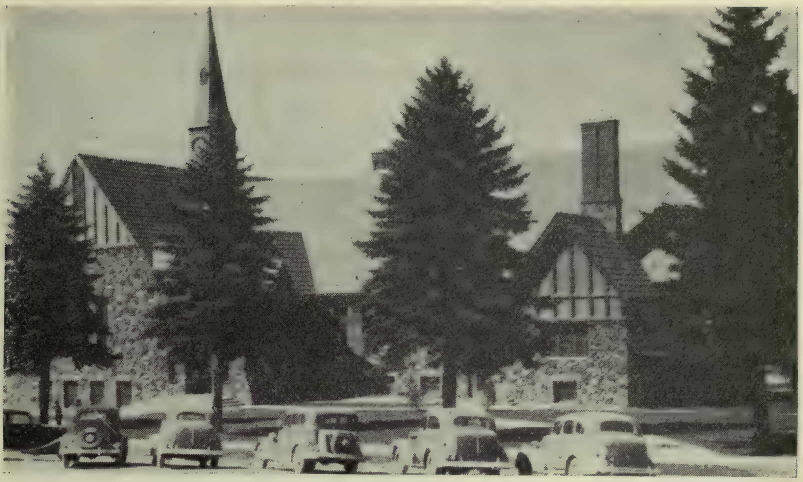
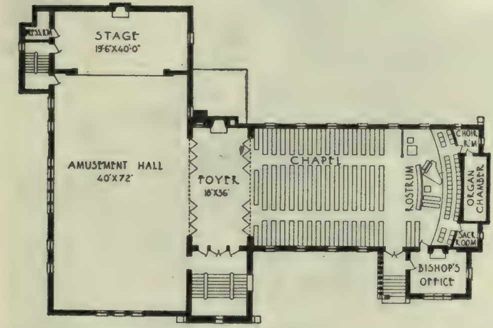

DOWN
BEDROOM
CLASSROOM
DOCTOR'S OFFICE
KITCHEN
12'-0" X 13'-6"
LIBRARY
17'-0" X 18'-0"
STAGE
STUDY
WAITING ROOM
PORCH
DOWN
DOWN
GAME ROOM AND AUDITORIUM
48'-6" X 29'-0"

FIGURE 12.—The Shannondale Community House, at Gladden, Mo. This is an example of a church and community-center arrangement. Space is provided for church, social functions, folk-school classes, and the minister's living quarters. This building, constructed of native stone, cost $9,000.




STAGE
19'6"X40'-0"
AMUSEMENT HALL
40'X72'
FOYER
18'X36'
CHAPEL
ROSTRUM
CHOIR R'M
ORGAN CHAMBER
SACR. ROOM
BISHOP'S OFFICE

FIRST FLOOR PLAN

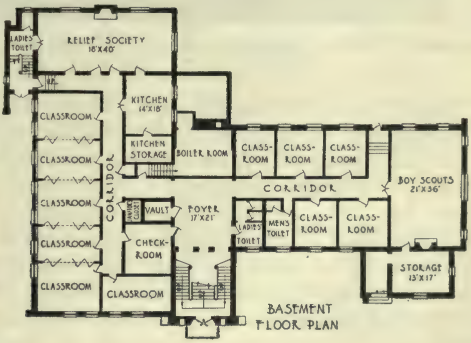

LADIES TOILET
RELIEF SOCIETY
18'X40'
KITCHEN
14'X18'
KITCHEN STORAGE
BOILER ROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CLASSROOM
CORRIDOR
CLASS-ROOM
CLASS-ROOM
CLASS-ROOM
CORRIDOR
BOY SCOUTS
21'X36'
JANITOR CLOSET
VAULT
FOYER
17'X21'
LADIES TOILET
MENS TOILET
CLASS-ROOM
CLASS-ROOM
CHECK-ROOM
CLASSROOM
STORAGE
13'X17'
BASEMENT FLOOR PLAN

FIGURE 13.—Latter Day Saints Chapel and Amusement Hall, Cedar City, Utah. A typical arrangement with auditorium and stage connected with the main chapel by the church foyer. The ground floor provides for the church auxiliaries, food service, Sunday-school classrooms, and Boy Scouts' room.

for church services, theatricals, dances, banquets, lectures, religious group gatherings, and patriotic meetings. It is somewhat larger than the average chapel in Utah, but its arrangement is typical.

LIBRARIES WITH AUDITORIUMS AND CLUBROOMS

Many libraries have been built with some space for community activities. The Carnegie Libraries in Braddock, Homestead, and Duquesne, Pa., each have an athletic club, a theater, and classrooms, in addition to library space.

The Tracy Memorial Building, at New London, N. H., a gift to the community, was a fine old residence. It has been remodeled for library and community use. It contains a clubroom, space for food service, and a community hall. The women's clubs, 4-H Clubs, and the farm bureau all use it, and it is well known for its adult forum that is made up chiefly of farm families. The building is outstanding in the attractiveness of its furnishings and in its gardens (figs. 14 and 15).

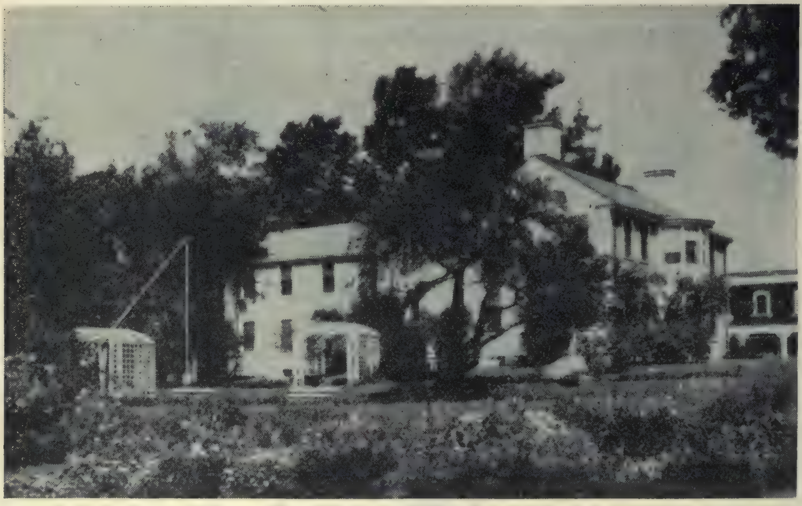


FIGURE 14.—This old dwelling was remodeled into a library and community building and presented to New London, N. H., by one of the residents.

Many new libraries, particularly those in small communities, are being built with community rooms. Sequim, Wash., has a population of about 500 people and is surrounded by an agricultural and forest-working community. A well-designed library and recreation hall has recently been completed that serves as headquarters for the local library and as a meeting place for many civic and social groups. The building (fig. 16) was financed by the Works Progress Administration and the community. The Sequim Women's Club and the local American Legion post were active sponsors.

GRANGE HALLS

In some rural places Grange halls have become the center of community life. Often they are in constant use. As these halls usually

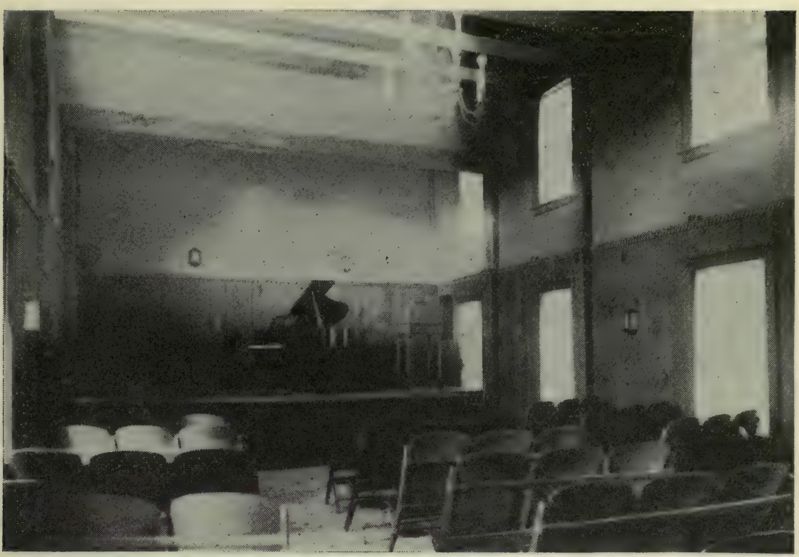


FIGURE 15.—A clubroom in the Tracy Memorial Building, at New London, N. H.

have auditoriums with stages, a well-equipped kitchen and dining space, and occasionally an additional room for juvenile Granges, they can easily be used by other organizations. Some of the recently built Grange halls include moving-picture booths and recreation equipment. In many of the small, rural places Grange halls have been inexpensively remodeled from abandoned rural churches and school buildings. The success of this remodeling depends on the design and structural condition of the old building. An inexpensive Grange hall, however, can often be made an attractive and useful community hall.

4–H CLUB BUILDINGS

Buildings for 4–H Clubs have increased rapidly because of the needed space for their club activities. Many 4–H Club buildings are successfully planned as community buildings, for they are suitable for the use of other organizations. For this reason, 4–H Clubs are usually one of many organizations using a community building.

Other types of 4–H Club buildings designed for 4–H Club State camps have been built in a few States. On the Massachusetts State College campus is an attractive clubhouse, planned for 4–H Club members in connection with State camp work. It is also the meeting place for other groups (figs. 17 and 18).

A few States have State 4–H Club buildings chiefly financed by State legislatures. These are designed mainly for 4–H Club activities and exhibits, but they are used somewhat by other organizations. The Nebraska building is a successful example of this type. It cost about $150,000 and provides for extensive demonstration and exhibit space.

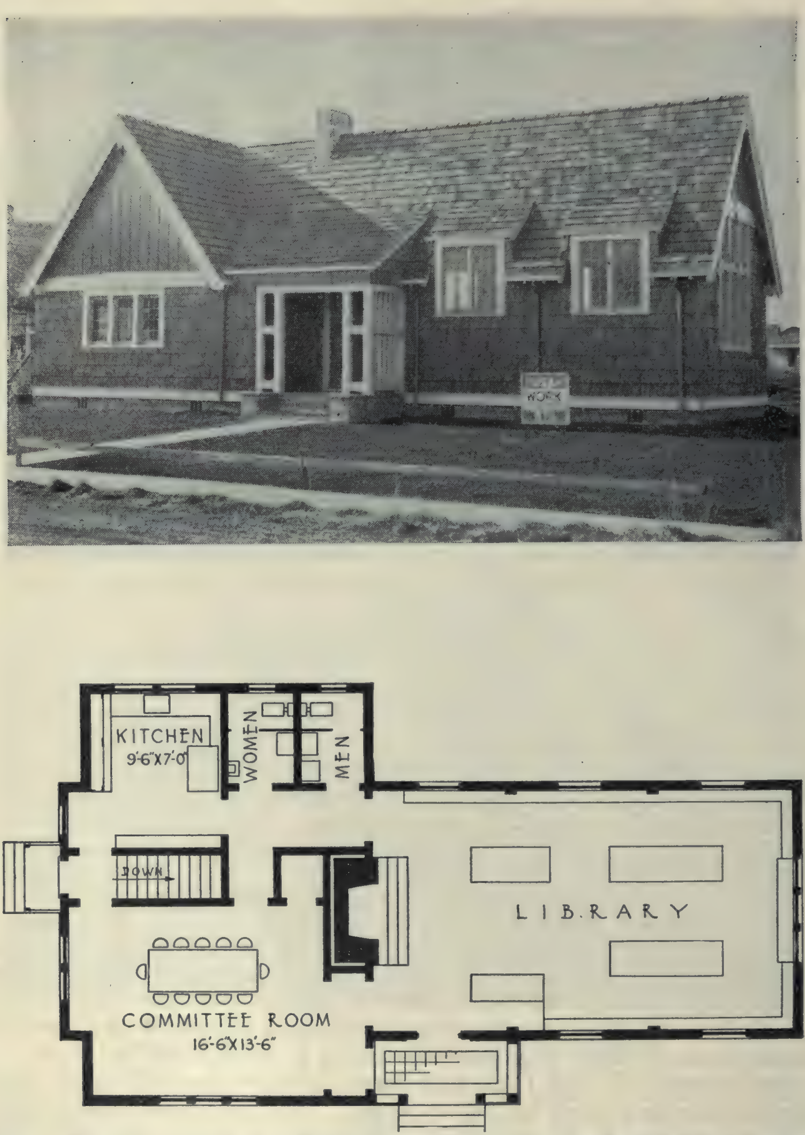

KITCHEN
9'-6"X7'-0"
WOMEN
MEN
DOWN
LIBRARY
COMMITTEE ROOM
16'-6"X13'-6"

FIGURE 16.—An example of a well-designed library and community building that serves a very useful purpose in the little town of Sequim, Wash. The roof and walls are of hand-split, western red cedar shakes, and the interior is finished with native woods. Its cost was only $6,792.

The building at Hutchinson, Kans., that was financed by the State, the Public Works Administration, and the Kansas State Fair, is another successful 4–H Club building. It has dining and kitchen service, dormitories, an auditorium, and exhibit space.

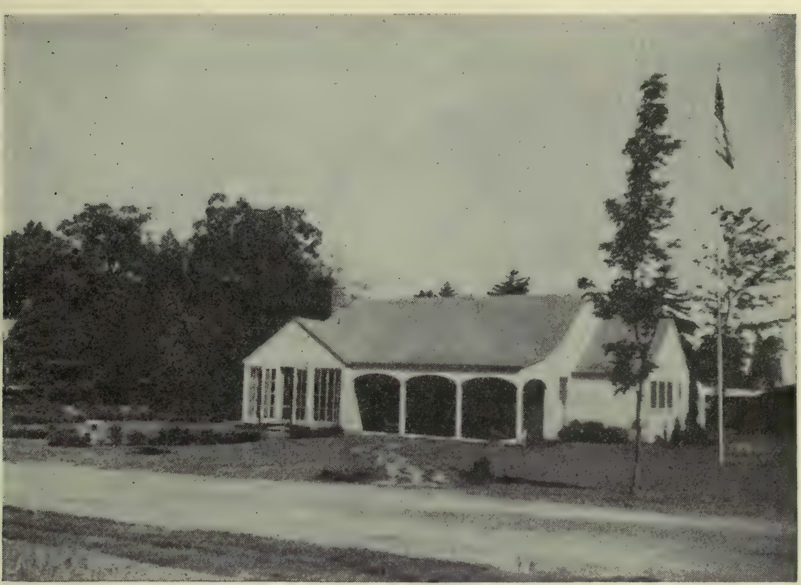


FIGURE 17.—The Farley 4-H Clubhouse, located on the Massachusetts State College Campus, is an example of well-designed and successfully planned building. The main hall, 26 by 40 feet has a stage, a fireplace, and a well-equipped kitchen adjoining. The building cost about $4,000. The money was raised by club members and their friends.

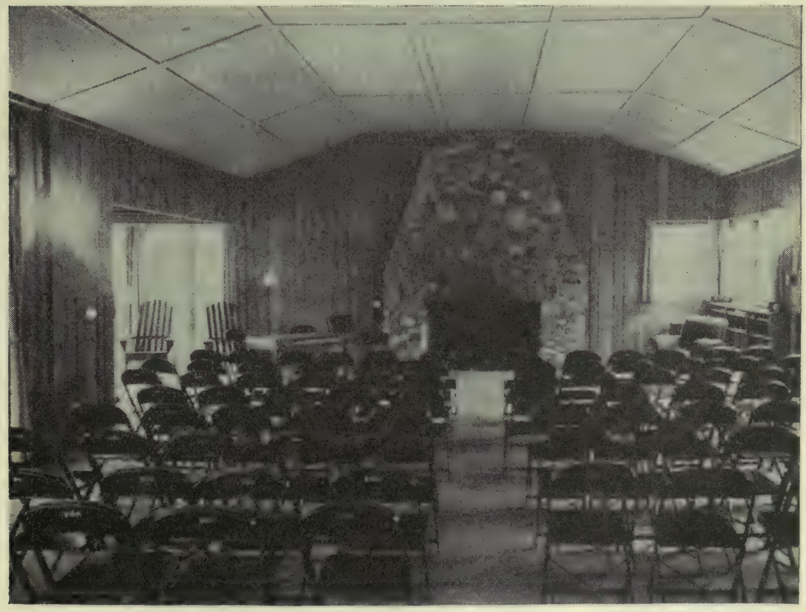


FIGURE 18.—The main room of the Farley Clubhouse becomes a pleasant auditorium.

HOME BUREAUS, HOME DEMONSTRATION CLUBHOUSES, AND CANNING CENTERS

In some States, particularly in New York, home bureaus, where country women may meet for assistance and instruction in the work of the home, have been organized. Some of the buildings that house these organizations are used for both educational and social activities, and they serve as the community house for the locality. Others are designed mainly for home bureau work. These are usually financed by the bureau's funds.

Many home demonstration clubs have houses or rooms for home demonstration work. These are often small and simply designed and represent only a small expenditure. Some of these clubhouses are used for many community activities and serve as the only community house in a small, rural locality. County home demonstration agents have been responsible for much of this building program.

In Georgia the agricultural extension engineer has designed a very simple standard plan for these clubhouses that has been used extensively in that State (fig. 19). With small adaptations and necessary changes for types of sites, this plan seems to be most suitable if a very small building is desired. The size of the main room of the Georgia plan is frequently changed to meet local needs, and a porch has sometimes replaced the terrace (fig. 20).

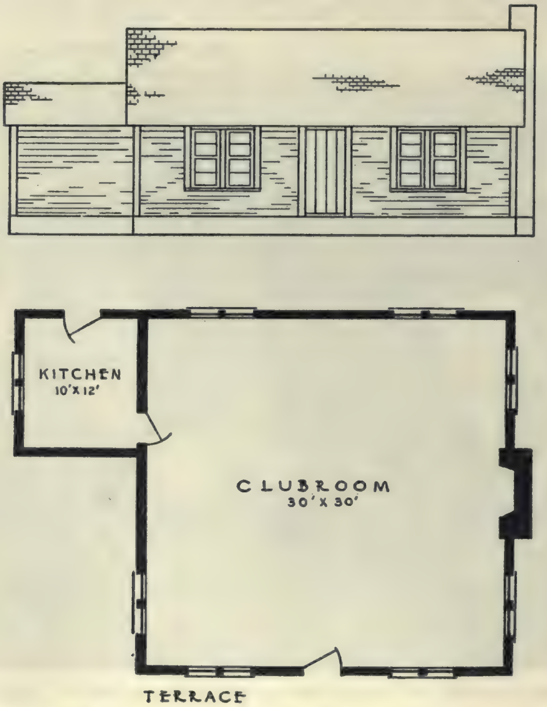


FIGURE 19.—Design for a very small clubhouse suggested by the Agricultural Extension Engineering Service, Georgia State College.

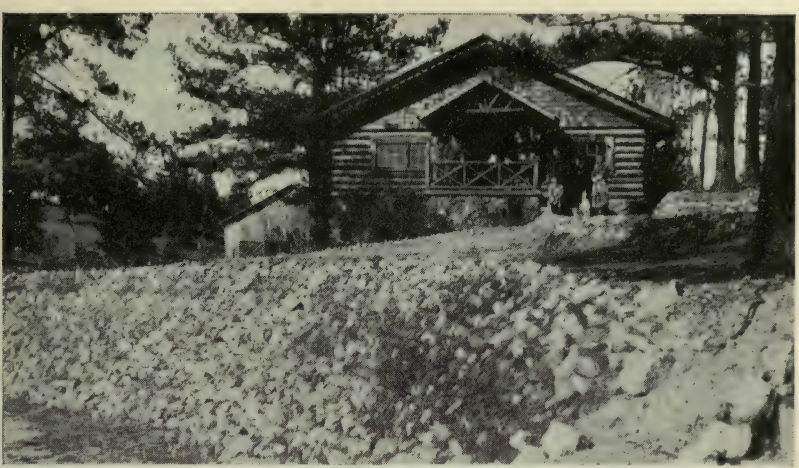


FIGURE 20.—One of the home-demonstration clubhouses of Polk County, Ga., adapted from the standard plan (fig. 19). This building of log-and-shingle construction was built with a cash outlay of only $450. The lot and labor were donated. It is a good example of a simply designed building well placed on a hillside location.

In many country communities, canning centers have been set up. In some places the canning center has its own separate building that is used for this single purpose (fig. 21).

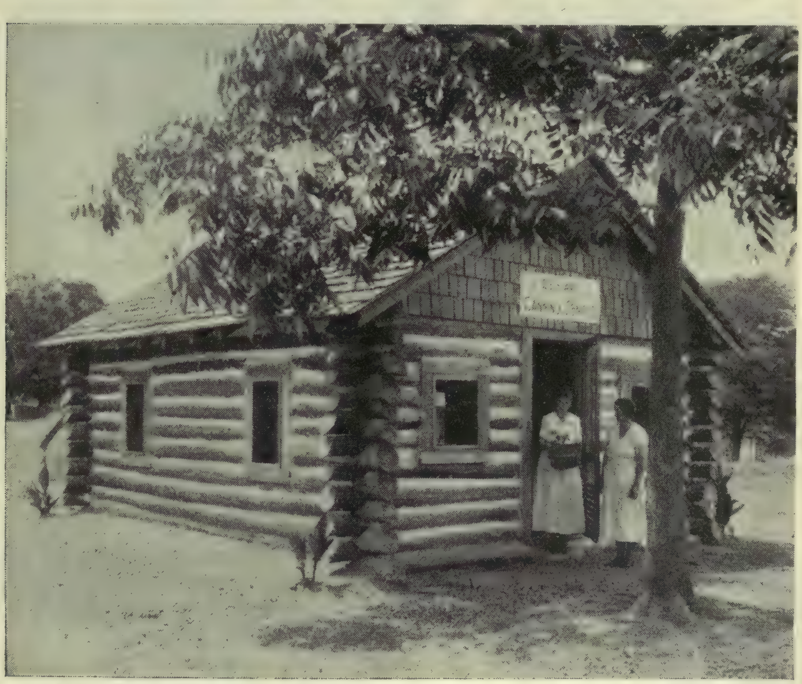


FIGURE 21.—Canning center at Des Arc, Ark., ready to be equipped. A very small building can be made very attractive.

Canning kitchens are planned also as part of community clubhouses. When they are well planned, adequately equipped, and located conveniently for the people, they become of great economic value to farm families. Many of these very small centers are built inexpensively by using local materials (fig. 22). (For information regarding the lay-out and equipment of canning centers, see Community Canning Centers (mimeographed) U. S. Bureau of Home Economics.)

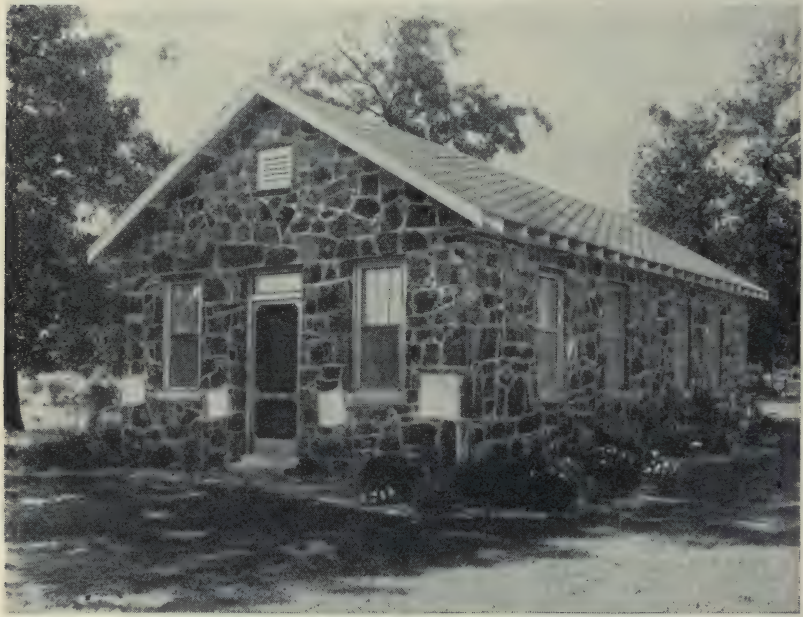


FIGURE 22.—The Adkins community center and canning kitchen, sponsored by the home demonstration club of Pope County, Ark., is an example of good design with the use of local materials.

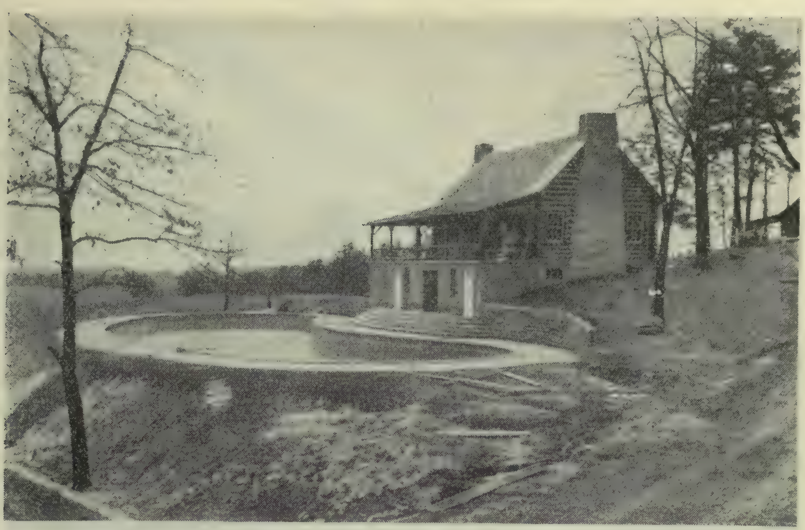
SHELTER HOUSES

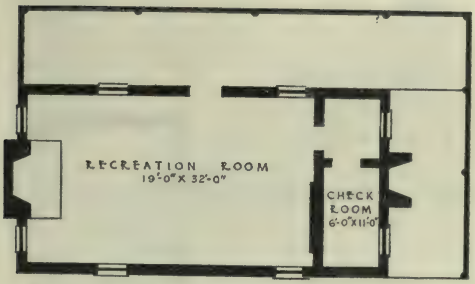
Many shelter houses have been planned as part of the recreation facilities for a playground or pool. A few have included social rooms or clubrooms. These rooms are commonly used for handcraft, orchestra practice, and dramatic rehearsals. Some of these houses show the importance of good design and careful planning even in small buildings (fig. 23).

SPECIAL COMMUNITY BUILDINGS FOR SPECIAL PROJECTS

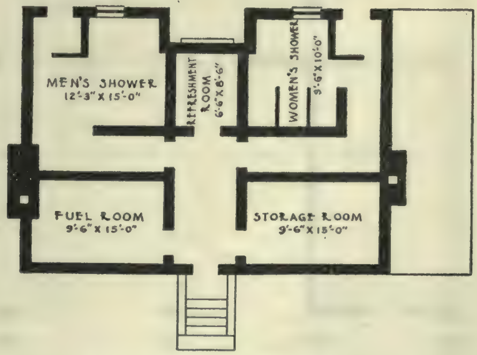
Community buildings that are designed for special types of projects are rarely suitable for exact duplication, but many of their features—type of building, room sizes, interior arrangement, and equipment—are worthy of consideration in other places.

Baxter Community, near Phoenix, Ariz., is a Farm Security Administration part-time farming community of about 35 families. A cooperative dairy, poultry, and truck farm is expected to provide food. In addition, each family has about one-fifth of an acre of land.




RECREATION ROOM
19'-0" X 32'-0"
CHECK ROOM
6'-0"X11'-0"

FIRST FLOOR PLAN


MEN'S SHOWER
12'-3" X 15'-0"
REFRESHMENT ROOM
6'-6"X8'-6"
WOMEN'S SHOWER
9'-6"X10'-0"
FUEL ROOM
9'-6" X 15'-0"
STORAGE ROOM
9'-6"X15'-0"

GROUND FLOOR PLAN

FIGURE 23.—Community building and shelter house located at Stearns, Ky. It is well planned for local meetings and recreation and is supervised by the school board.

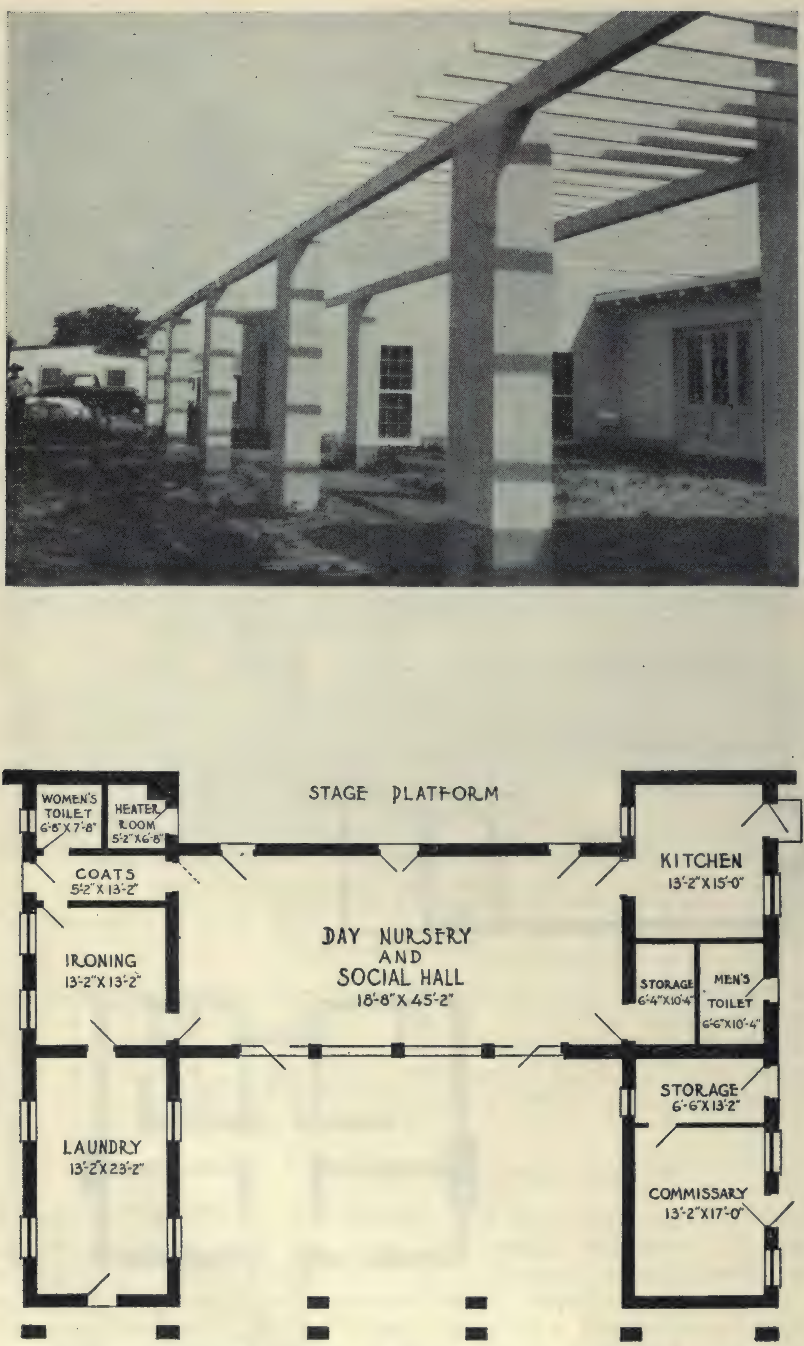

STAGE PLATFORM
WOMEN'S TOILET 6'-8"X 7'-8"
HEATER ROOM 5'-2"X6'-8"
COATS 5'-2" X 13'-2"
IRONING 13'-2"X 13'-2"
LAUNDRY 13'-2"X 23'-2"
DAY NURSERY AND SOCIAL HALL 18'-8" X 45'-2"
KITCHEN 13'-2"X 15'-0"
STORAGE 6'-4"X10'-4"
MEN'S TOILET 6'-6"X10'-4"
STORAGE 6'-6"X 13'-2"
COMMISSARY 13'-2"X17'-0"

FIGURE 24.—The community building at Baxter Community, near Phoenix, Ariz., is of adobe walls with earth roof. It was erected by the Farm Security Administration. The commissary manages the food for cooperative farms, and the well-equipped laundry rooms and nursery are for the use of 60 families.

A community building has been planned for the 35 families of this project and for 25 additional families of the nearby Phoenix Homesteads. Unusual features in this building are the commissary for the produce of the cooperative farm and the well-equipped laundry rooms. The houses for the families are small, and having the laundry rooms in the community building means that more space is available for other uses in the homes. This arrangement also gives families far better laundry equipment than they would be able to buy for themselves (figs. 24 and 25).

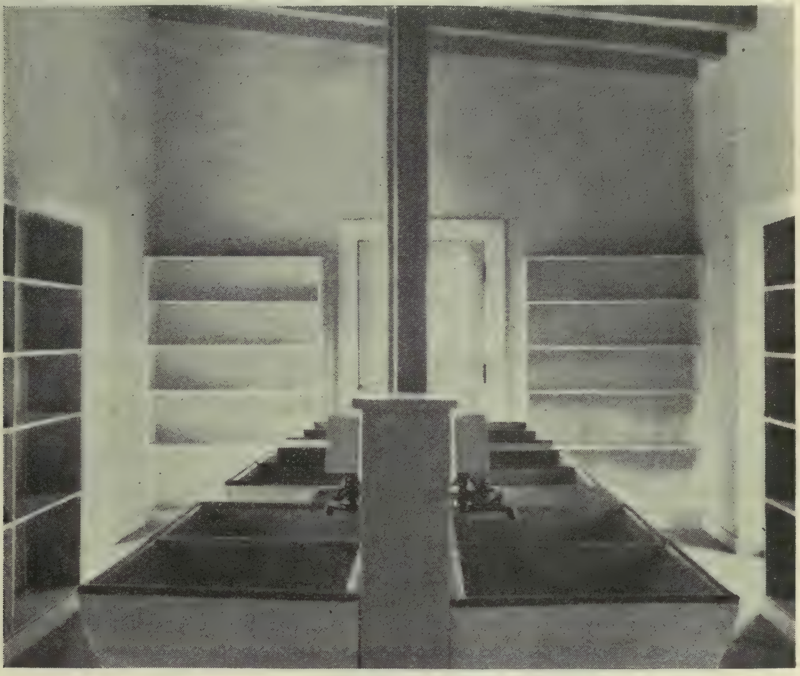


FIGURE 25.—The laundry room in the Baxter Community Building is generously equipped with trays and built-in shelves. The ironing room adjoins it.

When the town of Norris, Tenn., was planned, a community house was built for the thousand or more workers on the dam and the people of the village of Norris. Now the building is used successfully by the townspeople. Its room sizes and arrangements, its window and door placements, and its auditorium and stage, are of interest to those planning to build. It cost about $35,000 (fig. 26).

These community buildings in Tennessee Valley Authority camps, although required only for a few years during the construction of the dams, may be of interest to people in many small places. They show how activities can be successfully combined. The building for the Hiwassee Dam in North Carolina has a combination gymnasium-auditorium, a lounge, a library, a four-room school, a fire-truck room, police headquarters, a post office, a barber shop, a commissary, rest rooms, and several offices—all under the same roof. Space for these activities may be needed in almost any small community.

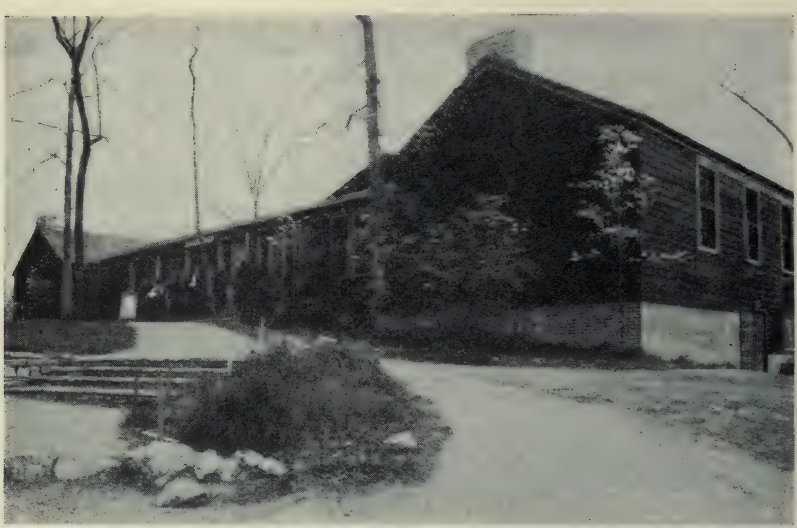


FIGURE 26.—The community building at Norris, Tenn. Originally designed for 1,000 or more workers, it provides for the business and social activities required in any small community. It has a large auditorium and stage, a kitchen and dining space including a soda counter, ample lounge space, a beauty parlor, and a barber shop.

INEXPENSIVE BUILDINGS

To be useful, community buildings need not be costly. Many small, inexpensive ones serve great needs. The people themselves have definitely wanted them and they have obtained them. They have paid for them dollar by dollar. They like using the buildings when they are completed.

Many little buildings that have a great many uses have been started with but a very few dollars—sometimes less than a hundred—for this has been all that the community could get together. Some of them have been completed through an earn-as-you-build program, going on year after year, with each small sum used to make the community house more comfortable, more beautiful.

The Eleven Points Community at Riverton, Oregon County, Mo., is a truly rural community, for it is located 5 miles from a church and 14 miles from the nearest town. The Eleven Points Club decided that a church and community building was greatly needed. During 1934 the club raised only $89, but on the strength of this sum they began work on the building. The site was donated, the cornerstone was laid and labor and some materials were given. In 1935 a native-stone building 28 by 40 feet was dedicated. Now that the building is complete, church services are held, the Sunday School attendance has doubled, a singing school has been organized, 4-H Clubs have been sponsored, and many social gatherings are held there. This building has become a real social center.

Many of these undertakings have been successfully carried through with very small amounts of money but with great enthusiasm and complete cooperation.

The following illustrations (figs. 27–29) are examples of successful but inexpensive community buildings.

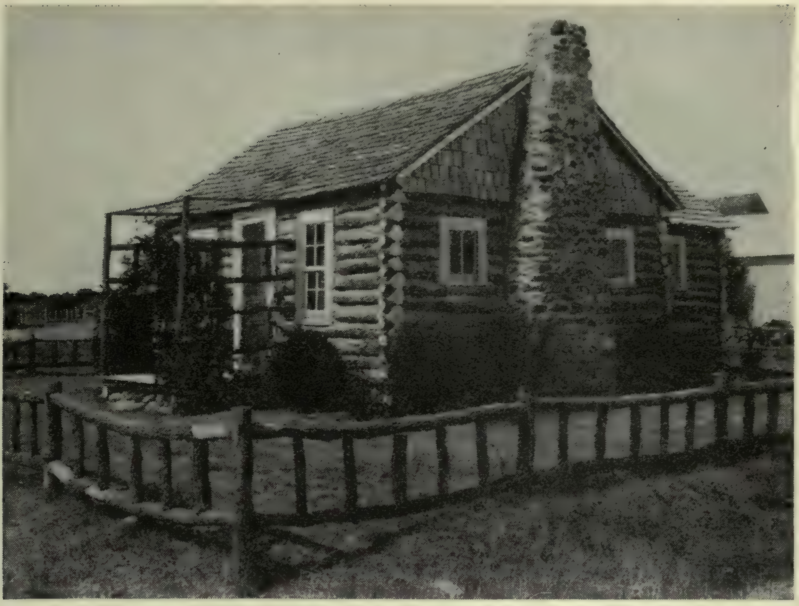


FIGURE 27.—The clubhouse at Kaufman County, Tex., is a good example of native materials attractively used in a small, inexpensive building. It has a clubroom 16 by 20 feet and a kitchen 12 by 14 feet. The women of the community raised the funds, and the men gave the labor. The cash outlay was only $100.

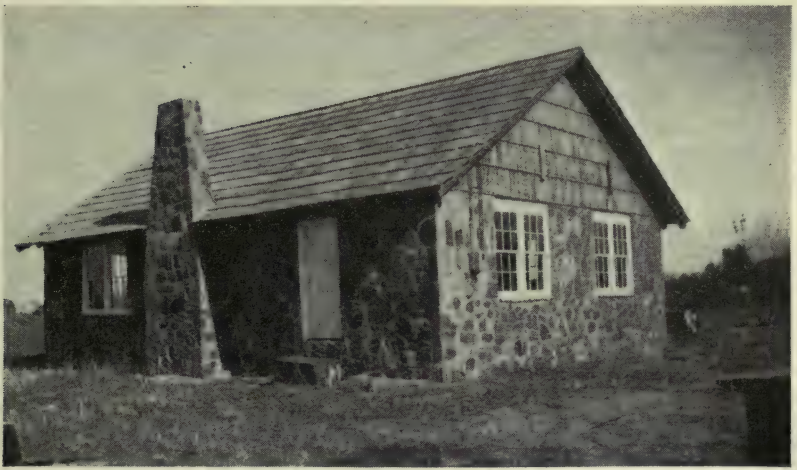


FIGURE 28.—There was only $675 available to build this native stone and shingle community house at Rose City, Pulaski County, Ark. This fund was raised by the home demonstration club. A local bank gave the site. Some material came from an abandoned church; some was donated. Men and boys cut logs for rafters, hauled rock, and salvaged the materials from the old church. The main room is 30 by 40 feet, and the plan calls for two additional rooms—one an auditorium with stage.

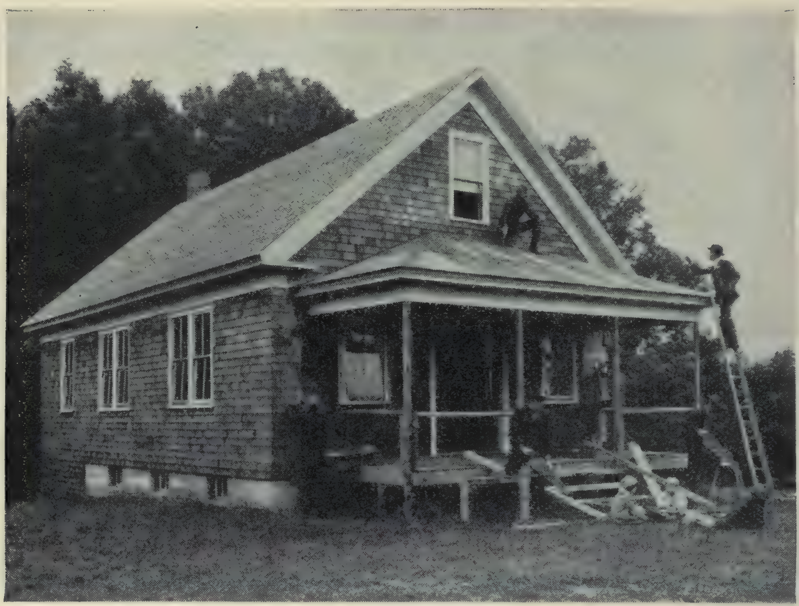


FIGURE 29.—Community house at Province Road, Belknap County, N. H. The locality in which this community house is situated has only a few families, but these families had no meeting place, no Grange hall. One evening the neighbors decided to build a community house; and the morning after, they had started work on it. The lot was donated; the school board gave an abandoned furnace; the maple flooring came from a local maple orchard; and the pine for the walls was given by wood-lot owners. Much of the labor was volunteer. The building has an auditorium and stage on the first floor and a kitchen and dining room in the basement. It is used mainly by the Grange.

WHAT TYPE OF BUILDING DOES A COMMUNITY NEED?

Before a community undertakes to plan or to build a community house, it should study community needs, for both replanning and duplication of space are costly. What organizations already have buildings or rooms that are satisfactory? Which activities can be combined? Can business and social groups be housed under the same roof, and how much space will they require? Do many of the people want ready-made amusements in the nearest large town instead of home diversions with home people? To what extent will the little country community content itself with itself, if the social interests of the people can find expression at home? As not all community buildings have been successful, serious consideration should be given to the building project before it is carried through. The most successful community buildings—those most used and most enjoyed—are the ones really required to house activities.

A careful study of the community's needs is sure to mean money saved, or at least money wisely spent. An auditorium, for instance, can be planned for many groups and many activities. It may be a lecture room, a moving-picture theater, a banquet room, a gymnasium, a dance hall, and if it is cleverly planned, its space may be divided for intimate small groups. There is good economy in planning each room for many uses, so in listing a community's needs it is always well to make the space in a single room useful for many purposes. Make every cubic foot of the building work full time.

THE COST

Few communities can afford to build as large a building as they want. The perfect building usually costs too much. In estimating the money required for a new building, future needs should always be considered, for there is little economy in cutting down the cost of the original unit to the extent that new, expensive additions must be added within a year or two. Inferior-quality building materials are not economical, for replacements and repair may also be costly.

After the community's needs are finally decided, and a conclusion is reached on the space required, any builder can give a rough estimate of the cost, if he has a sketch plan of the lay-out and some idea of the materials to be used. It is never worth while to plan on the cost of the building being less than the estimate. It is usually more, for extra needs creep in at the last minute. A contingency fund should be provided for these extras.

Buildings are usually estimated on cubic-foot cost, but estimates can also be made on square-foot cost.

The University of Arkansas estimated the square-foot cost of community buildings in Arkansas in 1935 at $1 a square foot of floor space, provided a large proportion of native materials were used. (Arkansas Agricultural Experiment Station Bulletin 322, Rural Community Building Plans.)

Only suggestive costs can be obtained from comparisons of costs of buildings in other places as there is such a difference between localities in material and labor costs, the amount and type of equipment, interior finish, and other items. But a general idea of the probable cost can be obtained.

The town hall and community building at Stanwood, Wash., completed in 1936, is a concrete, one-story structure, 62 by 72 feet, that cost about $18,000, exclusive of the site (exterior and plan, fig. 1).

A brick-and-tile, one-story building 55 by 115 feet has just been built in Pittsville, Wis., for $30,000, exclusive of the site.

The one-story, stone community building at Fort Stockton, Tex., built in 1936, with over-all dimensions 49 by 61 feet, cost about $10,000—materials about $5,500, and labor about $4,600 (exterior and plan, fig. 5).

The large, many-use, one-story frame building designed by Tennessee Valley Authority and built in 1934, cost about $35,000, exclusive of the site (fig. 26).

Many very small clubhouses and community buildings built recently cost less than $1,500 and many others less than $1,000, including the value of donated labor and materials (figs. 20, 27, and 28).

The Henshaw Homemakers' Club, Henshaw, Ky., is building a log community building 20 by 50 feet that is expected to cost $750. The lot was donated.

A one-story, two-room, log-and-shingle building in Polk County, Ga., having a main room 29 by 29 feet and a kitchen 12 by 14 feet, was built recently for about $950—materials cost $450 and the value of the donated labor was about $500 (figs. 19 and 20).

WHO PAYS THE COST?

There are a number of ways to finance community buildings, any one of which may be successful. Usually, the buildings are financed by a combination of methods. The most common methods are here outlined.

(1) *Taxation.*—In some places funds are obtained through taxation. This method is commonly used when community buildings are combined with school buildings. Some township governments finance both the capital and operating cost of the community building. The usual procedure, under the taxation method of financing, is to submit the proposition to the vote of the people and then, if the vote is favorable, borrow the money by issuing bonds.

(2) *Individual gifts.*—In a few communities individuals have given buildings for community use. Such instances are uncommon.

(3) *Community sponsors and the Works Progress Administration.*—A great many community buildings have been built lately through funds provided by the Works Progress Administration for relief labor, combined with community funds. Some very useful buildings have resulted. Since the Works Progress Administration is a temporary organization, its future financing of structures is doubtful.

(4) *Sale of stock.*—Some communities have organized stock companies to finance community buildings. Stock is issued in small-amount certificates, sometimes as small as $5 each. These are sold to individuals. Usually the amount sold to each person is limited in order to distribute the cost and spread the ownership among many people. · This method of financing, through small-amount stock certificates, usually is very successful and results in community-wide interest in the building.

(5) *Donations of money or labor by the people of the community.*—Many small community buildings and some large ones are financed entirely by the people themselves, all families giving or working in one way or another to pay costs. When people pay they feel that they own. Usually some club takes the initiative and raises funds through entertainments. Donations in cash or labor, or both, are also made, or private subscriptions are solicited. If subscription funds are not adequate, a loan is frequently made by some community organization. Some of these small buildings have been started with a very small cash outlay, sometimes as little as $100.

Buildings used by special groups such as the Grange, churches, and various types of clubs, are financed chiefly through their memberships and through funds raised by entertainments. Most Grange halls, for instance, are financed through funds from entertainments and donations. The remainder of the debt, if there is one, is taken care of in the form of a loan made by an officer of the Grange to the Association.

Some clubs build one unit of the building and add to it as funds permit. That is the way the club at Rose City, Ark., succeeded in getting a building.

LOCATION OF THE BUILDING AND SIZE AND TYPE OF BUILDING SITE

Where a community building is to be located will depend on the type of neighborhood in which it is to be built—farm and village or open country. Whatever the location, it should be easily reached by all the people; hence in many neighborhoods, road conditions will affect the location.

A great many community-building sites have been donated by individuals, civic groups, or business organizations. In such instances the location and type of site may not always be the choice of the community, but it may be the one way to get a community building started.

The size of the site will depend on the location and the type of center desired. If a community building is in a village, and it is to be used by both village and open-country organizations, for civic, social, and recreational purposes, the site probably cannot be large.

In Montana, where a study of community buildings has been made, 17 of 39 were on sites less than 1 acre in size, and 32 of the 39 had sites less than 5 acres in size.

If it is possible for the community building to be so located that plenty of ground is available, such features as tennis courts, a baseball diamond, horseshoe-pitching courts, a playground and wading pool, picnic grounds, and an outdoor theater can be provided. Two of these features—the outdoor theater and picnic grounds—have been increasingly used in country neighborhoods, and they are greatly appreciated in many places. Outdoor theaters for plays, concerts, motion pictures, lectures, and all types of festivals can create educational interest (fig. 30).

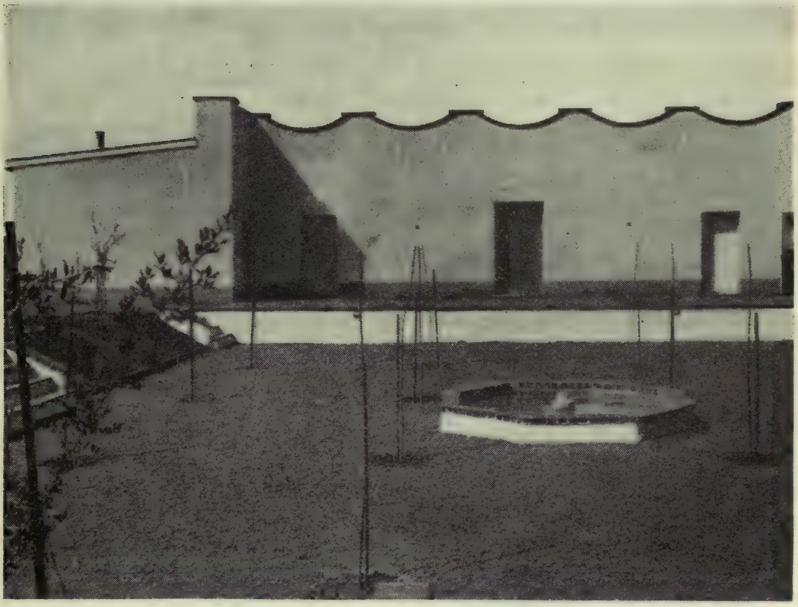


FIGURE 30.—A small outdoor stage for open-air meetings and entertainments is part of the Baxter Community building, Phoenix, Ariz.

If a large site is selected, the lay-out should be planned for future development, because large areas usually mean a build-as-you-can program with development as money permits. These large sites sometimes require 15 to 20 acres, if picnic grounds and athletic fields are included.

Whatever the size of the site, all natural beauty should be kept and not only used, but featured (fig. 31). If a hillside site is selected, attractive results may be obtained by carefully planning the building for the particular site, by terracing, and appropriate planting.

FIGURE 31.—An attractive garden adds to the beauty and use of a community house. (The Tracy Memorial Building, New London, N. H.)

A landscape plan for the grounds is important, for good landscaping adds to both the attractiveness and the use of the building. The out of doors is much more used for activities than it once was—for dramatics, lectures, music, dining, and many other purposes. It is usually good economy to employ a landscape architect to make the plan, but the development may be carried on from year to year by the people themselves with a little guidance. (For information on landscape plans for grounds of community buildings, see Illinois Agricultural Experiment Station Circular 470, Rural Community Buildings.)

ARCHITECTURAL DESIGN

A building need not be large or costly to be of good architecture, for some very small buildings are very well designed. Simplicity usually is the keynote to good design, for a simple building in good proportion is always more beautiful and more satisfactory than one with meaningless detail. When a community building is to be built it should conform to the architecture of the vicinity, and it should be in keeping with well-designed, nearby buildings.

An attractive building is always more valuable than an ugly one. Good proportion and good line in building costs no more than the lack of it, and the result is satisfying to everyone (fig. 1).

Common mistakes in buildings are the improper placement of the building on the site or the design of a building that does not suit its site. They occur most frequently in the use of irregular-shape lots, hillside, or sloping lots.

Many community houses are built of native materials because these are usually cheaper. With careful designing and study of the site and surrounding locality, these materials can be used most effectively and most attractively (figs. 2, 4, 6, 12, 20, 21, 22, 23, 27, and 28).

A community building of even moderate cost should be designed by a competent architect, for a good architect usually saves the people money and makes the building more valuable and useful.

CONSIDERATIONS IN PLANNING

The first step in planning is to decide on the community's needs. Are there satisfactory rooms, or buildings, or both, that are in use for some of the community's activities, and will they continue to be satisfactory? What uses and activities must be provided for at once in the building, and what are the probable future needs? It is always best to plan a building around the needs for which it is to be used, instead of attempting to fit the needs into the building after it is completed.

No building committee or architect can anticipate all future needs and uses, so the plan must be flexible. Most community buildings should be planned for future additions that can be easily and inexpensively made. If a many-use building is to be designed, a plan for all the community—old and young, men and women—is necessary; and it is good economy to make each room serve as many purposes as possible and make all the equipment useful.

There are no standard plans that will be entirely satisfactory for any given community, for needs differ in each place, and locations and sites differ. The plans of other buildings will suggest desirable arrangements, room sizes, and uses of materials. A particular unit, such as an auditorium, gymnasium, or clubroom, might be successfully copied from another building. It is important then for the planning committee to visit other community buildings of good design in the area.

THE ROOMS

Sizes and designs of rooms will depend somewhat on the number of people that will use them and the variety of uses. They will also depend on the money that is available. Since building is costly, all space should be used as much of the time as possible.

An auditorium, for instance, will probably serve for lectures, dinners, dances, and other social functions. It may be used as a gymnasium. Its size must be adjusted to the number of people that will use it and their activities. Six or seven square feet per person is usually allowed for seating arrangements. Dining space requires more area per person, depending on the size of the tables used. Usually 9 or 10 square feet per person is adequate. Many buildings now have moving-picture projection booths and sound apparatus. Most auditoriums have stages, and these require storage space for scenery, dressing rooms, and adequate exits. The movable stage that can be placed in the center of the room, at its ends, or sides has been very satisfactory where it has been used.

A gymnasium-auditorium will usually require more space than an auditorium. Such a building recently planned in a town of about

1,100 has outside dimensions of 66 by 114 feet. Its auditorium and gymnasium space is 40 by 75 feet, with a stage 18 by 36 feet. Bleachers that seat 600 are provided at the sides of the room.

Clubrooms will also vary in size according to the use to be made of them. Some space should be provided for quiet and passive games. Small library rooms are often used for club purposes.

Kitchens in rural community buildings, particularly those located in the open country, are usually planned for canning purposes as well as for food service for social functions. If a canning kitchen is to be used, a space 14 by 20 feet will permit as many as six persons to work effectively. It will also be large enough to serve moderately large groups. If the kitchen can be placed between the auditorium and a smaller room it will provide easy food service for both rooms or for small and large groups.

If rest rooms for the use of country people while carrying on their business in town are needed, there should be some arrangement for food service, comfortable chairs and couches, and preferably a small library and writing room.

Many satisfactory small clubhouses, some with only two rooms—an assembly room, 30 by 30 feet and a kitchen large enough in which to do canning—have been built at small costs (figs. 19 and 20).

Resident-type clubhouses with a main room, one or two clubrooms, and kitchen space also meet the needs of many rural communities (fig. 32).

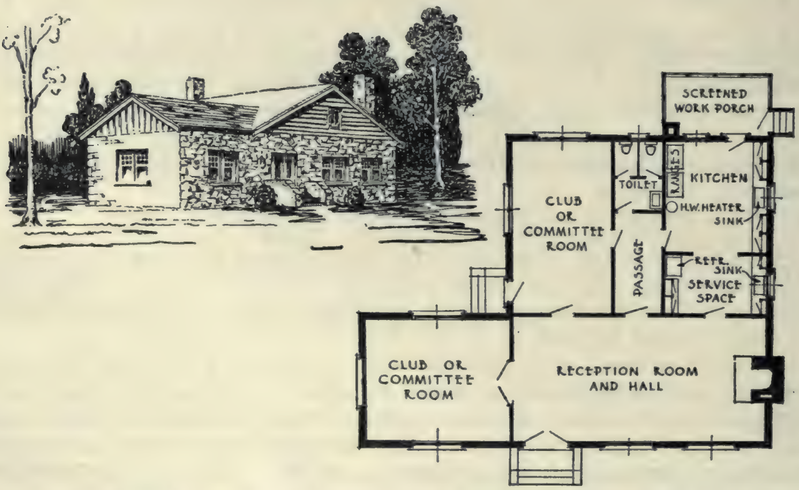


FIGURE 32.—A clubhouse 24 by 36 feet with a wing 18 by 20 feet. The kitchen is sufficiently large for doing some canning. The building contains about 1,220 square feet. (From Arkansas Agricultural Experiment Station, Bulletin 322, Rural Community Buildings.)

FIRE-PROTECTION AND BUILDING-CODE REGULATIONS

Whenever a building is planned for large or moderately large meetings or groups of people, protection against fire and other building hazards are necessary. Only a few States have building codes, but safety regulations, requirements for sanitation, and ventilation, usually exist. In some places any building that has a stage and curtain is classified under the theater regulations for safety. The requirements of the States differ. When a community building is to be built, plans for the building should be submitted to the proper State authorities for approval if local ordinances for safety regulation do not exist.

REMODELING OLD BUILDINGS

Many abandoned schoolhouses and some churches have been remodeled into successful community buildings. Others have been unsatisfactory because of one or more of the following difficulties: (1) The location could not be easily reached by all the people. (2) The architectural design and plan of the building could not be inexpensively adapted to changing needs. (3) Too much new construction would be necessary to warrant the cost of remodeling.

Many old buildings have been remodeled that are structurally sound but are architecturally ugly. If the proportions and the main lines of the building are good, remodeling may be satisfactory, for often unattractiveness is caused by a few details that can be eliminated. A community cannot afford ugly design, for the building is for the approval and benefit of all of the people; and other communities also may select it as a model.

Some of the old rectangular schoolhouses and churches with good lines, originally well built and still well preserved, have been successfully converted into small community buildings. In a few instances, a stage, partitions, and equipment have been the only essentials added (fig. 33). Sometimes it has been necessary to put in central heating, to partition off a kitchen, and provide storage space.

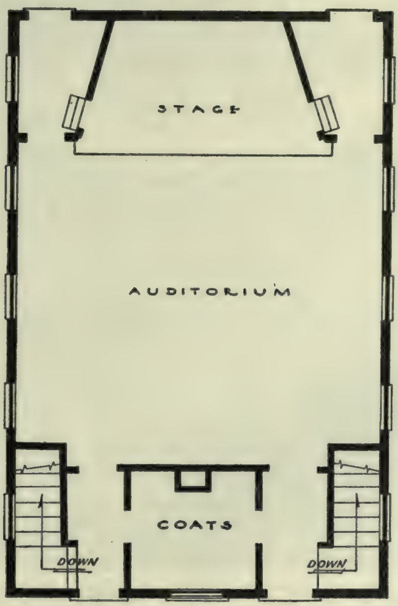


FIGURE 33.—Plan for converting a church into a community building. Seats have been removed, and the stage replaces the pulpit space. (From Illinois Agricultural Experiment Station Circular 470, Rural Community Buildings).

The clubhouse at Rose City, Ark., was built from the stone of an abandoned church. In this instance materials only were salvaged.

Success in remodeling depends on a careful study of the expenditures necessary to make the old building useful and attractive, for sometimes a remodeled building costs more than a new one, and usually it is not so satisfactory.

THE FURNISHINGS

Frequently too little consideration is given to the need for furnishings that are both useful and attractive. Attractiveness does not cost very much, and no one knows how high its dividends are (fig. 34).

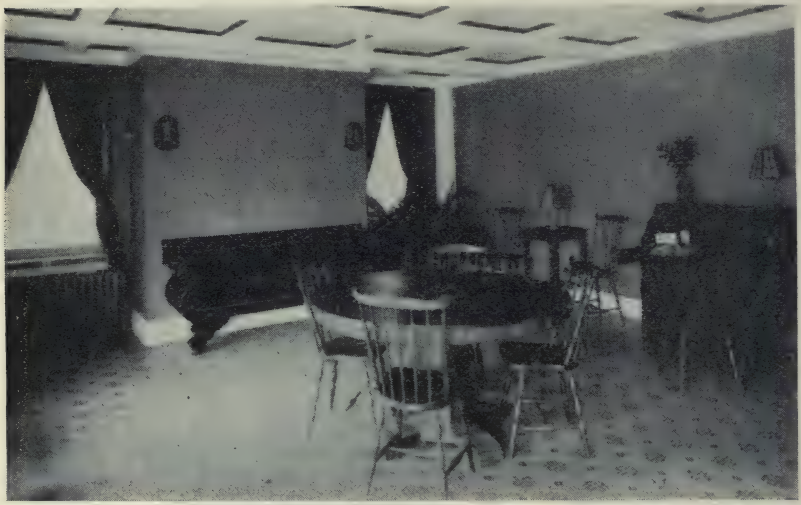


FIGURE 34.—Careful selection of furniture brings satisfying results. (Tracy Memorial Building, New London, N. H.)

As a community building is the people's building, the furnishings in it have influenced the home interiors of many communities. Pieces of furniture are copied, materials are duplicated, and color schemes are imitated. Furniture need not be costly to be useful and interesting. Cast-off pieces repaired and refinished can sometimes be made satisfactory and attractive.

In many communities the people have made many of the pieces of furniture. Furniture making is often a club project. Such a project has many advantages. The furniture can be made very attractive, it is cheaper, and it contributes to the well-being of the entire community (fig. 35).

It is often difficult to make large rooms attractive and to furnish them to serve small groups, as well as large. This can be done through skill in furnishing and arrangements. Assembly rooms need not be cheerless (fig. 36).

Community buildings are not often completely furnished at one time. There usually is not enough money. The common method is to buy the essentials, and then add pieces as funds permit. Many

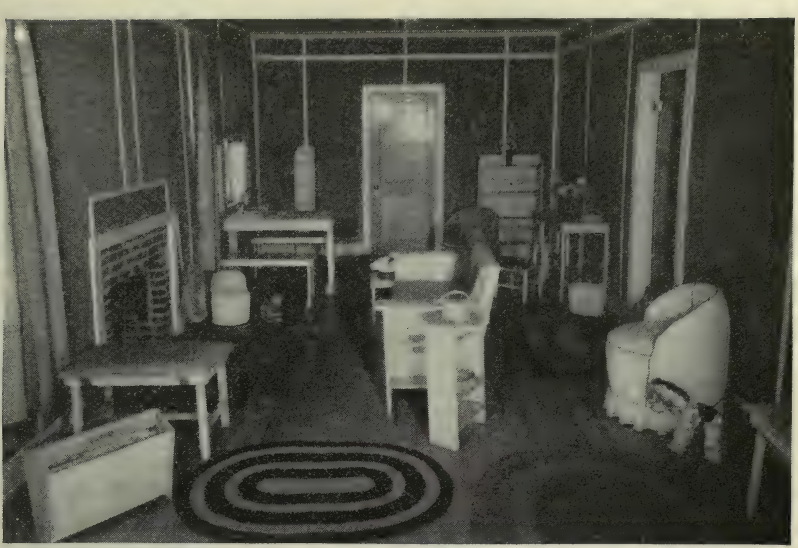


FIGURE 35.—Useful and attractive furniture for community houses can be made as well as bought. These pieces were constructed by workers of the Works Progress Administration at Camp Ocala, Fla.

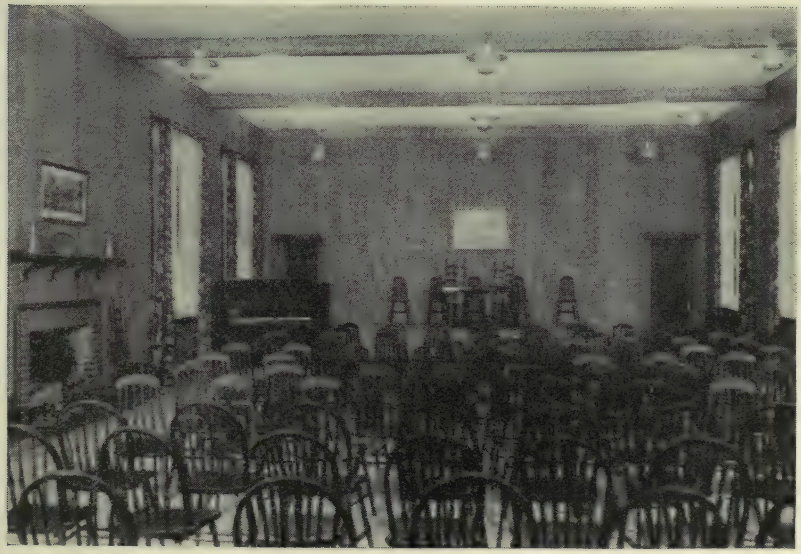


FIGURE 36.—This interior in the Millen, Ga., community building shows desirable furnishings for a large room. The exterior of this building is an example of good architectural treatment of a one-story frame building that cost $9,000 (cover illustration).

clubs have been responsible for the furnishing of community buildings, and these projects usually continue over several years. Whatever the method, the aim should be to satisfy the people who use the building.

ADMINISTRATION AND MANAGEMENT

Many community buildings have failed because of lack of management and proper administration. Every building, no matter how small, will require an organization to define its policy in reference to building uses, rentals if any, care and upkeep, hours, and other regulations.

Community buildings are usually controlled by the group that finances them. If this is a club or some other association, a board of directors is usually elected from the group to determine the policy. This board appoints its own officers. In some places a house manager or a committee is appointed to supervise the building. The title to the building usually remains with the financing groups.

School and community buildings are usually under the management of the school board or a board of directors.

When a building is given to a community by an individual for community use, a board of directors or trustees is usually appointed to control it. The title to the building, in most instances, remains with the individual.

Sometimes a building is financed through the sale of stock. In such instances, the association sponsoring the financing usually incorporates under the laws of the State. To do so is a convenience in holding property.

The constitution and bylaws for the operation of these buildings differ greatly, depending on the financing method and the size of the community. Usually a constitution defines the objectives of the organization and prescribes such items as the duties of the officers, types of membership, and voting privileges.

Good management can overcome the difficulties that arise in building uses and that arise because of friction between groups. Difficulties so serious that they have closed down buildings have sometimes arisen over uses of buildings. Uses by young groups have caused many of these difficulties. An adequate and clear definition of uses when the building is first opened should prevent such misunderstandings. If the management has a well-located, well-designed building to operate and takes advantage of the experience of others, it can make the building one that all the people will use.

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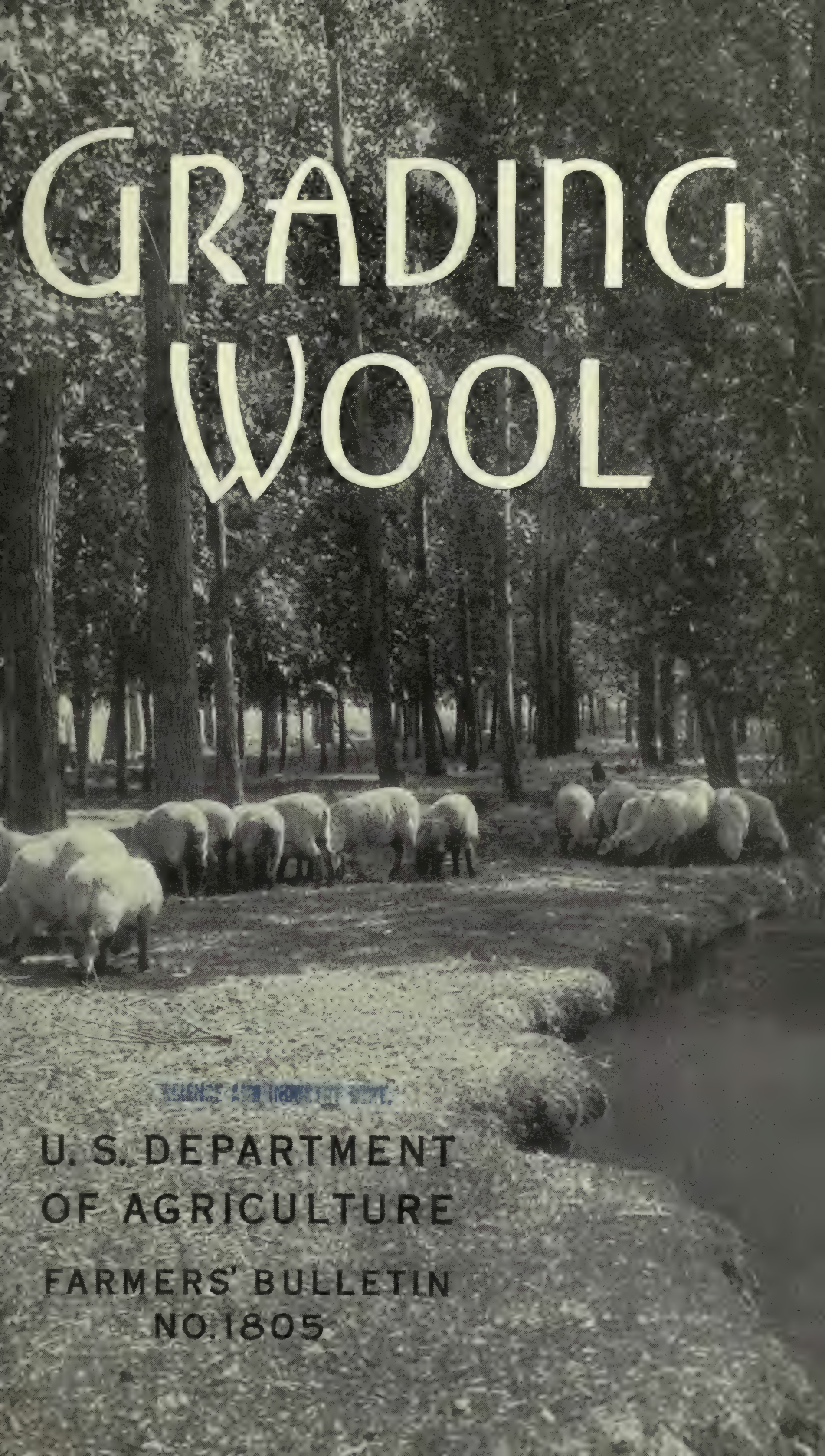
GRADING WOOL



SCIENCE AND INDUSTRY DEPT.

U. S. DEPARTMENT
OF AGRICULTURE

FARMERS' BULLETIN
NO. 1805

MOST WOOL GROWERS need to know more about wool grading, whether they expect to grade wool or not. This bulletin contains information about the subject so growers interested may improve their position when they are ready to sell their wool.

It also suggests ways to handle the wool so that its quality will be maintained through the shearing and the preparation of the fleece.

Washington, D. C.

Issued June 1938
Slightly revised January 1939

GRADING WOOL

By **James W. Christie**, *specialist in marketing wool, Bureau of Agricultural Economics*

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MOST WOOL GROWERS, especially those with small flocks, need to have more definite information on the grade of the wool they have to sell and its value. On the other hand, the buyer usually is well informed as to the market and knows values by grades. It is, therefore, to the advantage of wool producers to learn what they can about the grade and quality of their clips. This bulletin suggests how to go about learning something of grades.

THE WOOL-GROWING INDUSTRY

It is estimated that there are about 472,000 wool producers in this country and about 45 million sheep.

The wool clip of the United States has recently averaged about 350 million pounds of shorn wool a year. In addition to shorn wool, from 55 to 65 million pounds of pulled wool is produced annually, which is obtained from the skins of slaughtered sheep.

The wool-growing industry in this country has shifted westward until now two-thirds of the shorn wool is produced in the Rocky Mountain and Pacific Coast States. Texas is the largest producer.

In the East sheep are raised usually in small farm flocks of from a dozen to possibly a hundred head of shearing age. Such flocks are common as adjuncts to general farming, serving to utilize hill pasture and rough forage.

In the western range States, often called the "territory" States in the language of the wool trade, the sheep as a rule graze over the open range country both in winter and summer. They are run in bands of about 1,000 to 2,000, each band of that size usually having a herder. The sheep raiser in the range States will clip from a minimum of about 5,000 pounds up to as much as 400,000 to 500,000 pounds. Usually the clip runs from 25,000 to 100,000 pounds. In other words, in the West sheep raising is a large-sized business, whereas on eastern farms it is a minor enterprise.

Relatively little wool is produced in the Southeastern States.

Rambouillet or Merino blood is present in some degree in most of the sheep that produce the territory wool, grown in the Rocky Mountain States. Generally speaking, these wools are of the fine-wool type. In this region is produced most of the American wool.

East of the Rocky Mountains and east of the Edwards Plateau region of west Texas the Down breeds of sheep predominate and are of a coarser type. Exceptions to this are the wools produced in parts of southern Ohio and adjoining Pennsylvania and West Virginia, which are fine wools.

Territory wools shrink more (lose more weight in scouring) than do the eastern wools; and they are not so strong in staple as the latter, because of the influence of sparse forage and the alkali and dust picked up by the sheep as they graze.

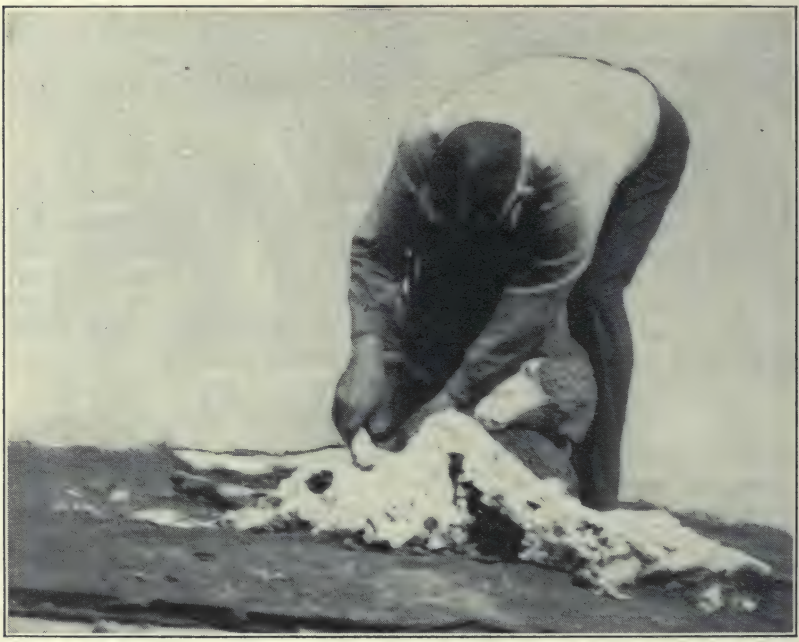
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FIGURE 1.—Shearing in such a way as to obtain an unbroken fleece.

Wools produced in the eastern farm States are called bright domestic fleece wools because they are but little discolored by foreign matter and as a rule shrink uniformly.

The shearing season in the United States usually begins in February in the Southwest, particularly in Arizona. As the weather becomes milder, during May and June, shearing gets well under way throughout the country, except in the North, where it is done during July. Proper shearing, preparation, and care of the fleeces are important points in marketing (figs. 1, 2, and 3). Shearing generally is done only once a year in the United States, but in California and Texas some sheep are shorn both spring and fall.[1]

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[1] For brief suggestions for the best ways of preparing wool for market see Leaflet 92, of the U. S. Department of Agriculture, Preparing Wool for Market.

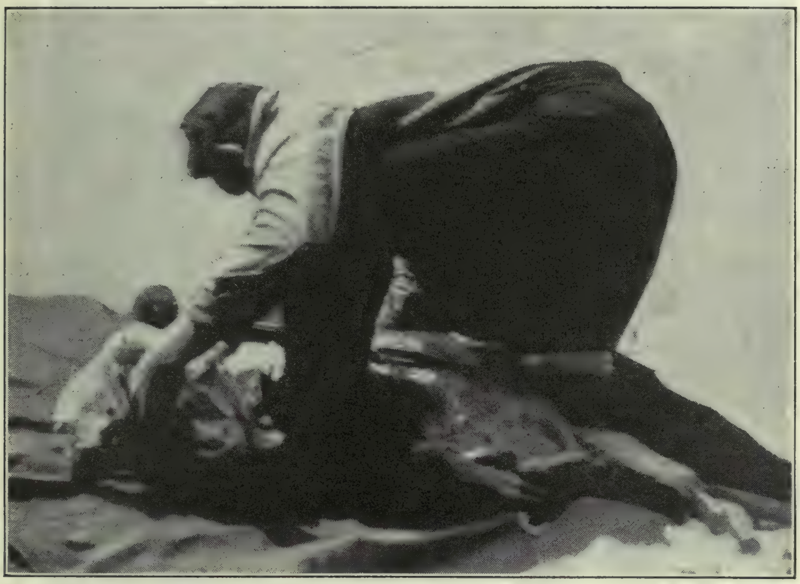

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FIGURE 2.—Best position for sheep during removal of fleece.

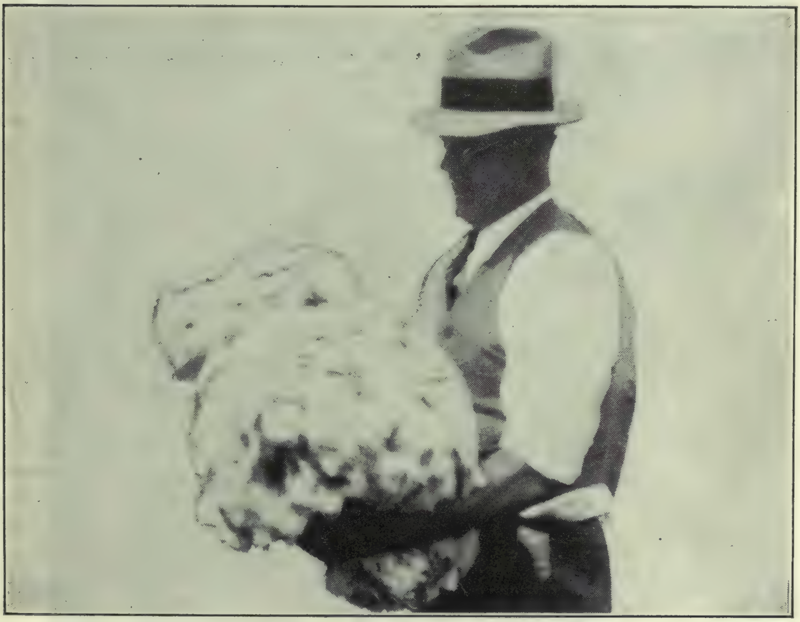

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FIGURE 3.—A finished, well-prepared fleece.

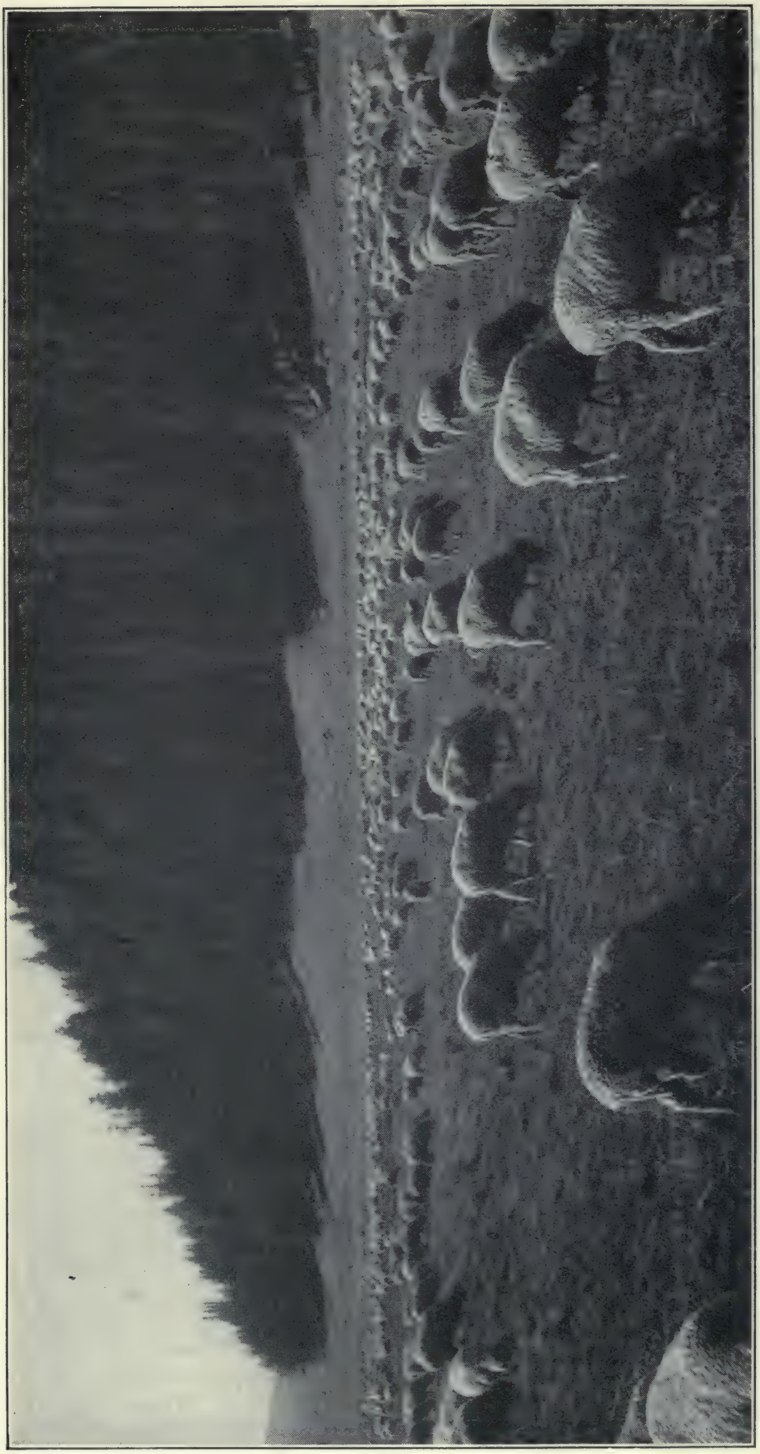

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FIGURE 4.—A range flock.

IMPORTS OF WOOL

Only about 60 to 70 percent of the wool consumed in the United States is produced here. Some 30 to 40 percent must be imported.

Foreign wools imported into this country pay, at present, a duty of 34 cents a pound, on the basis of the yield or scoured content.

As the United States produces little or no wool that is suitable for carpet or floor coverings, wools for this purpose are admitted duty-free. Such wools must be below a certain grade which is defined in the Tariff Act.

Wools from Australia and South America usually are very well graded and prepared for market and are preferred by certain manufacturers.

The chief ports of entry for foreign wool are Boston, New York, Philadelphia, and San Francisco. During the year ended December 1936 110 million pounds of apparel wool and 143 million pounds of carpet wool were imported into the United States.

QUALITY OF WOOL

Wool is a modified form of hair, differing from other hairs by having a crimpy or corrugated appearance.

No two fleeces of wool are alike. Furthermore, no single sheep will grow wool of the same character throughout, and fleeces from the same breed of sheep differ widely in many respects.

The characteristics or properties of wool that determine its value to the manufacturer are: Fineness or diameter of fiber, length of staple, strength, elasticity, crimp, softness, pliability, uniformity, color, luster, felting property, and spinning and working properties.

The fineness of wool is very important because the character of the yarns and fabrics produced is determined to a great extent by its variations in the diameter of the fiber. An ordinary sample of wool is not made up wholly of fine, medium, or coarse fibers; it is a mixture of a large number of each, but finer fibers and more of them occur in fine wool; medium fibers predominate in medium wool; and coarse fibers predominate in coarse wool. Fine wool is much more uniform than coarse wool. The value of fleeces varies chiefly according to whether the wool is fine, medium, or coarse (fig. 5).

Length of staple is also very important to the manufacturer. Fibers need to be of a uniform length, for it would be impossible to comb a uniform top (combed wool) or to spin yarn of even smoothness from wool containing both long and short staples.

Wool staples vary in length from about ½ inch up to 12 or 15 inches. They are divided broadly into two main groups, according to their adaptability to certain manufacturing processes. One group is known as the combing wools, and the other is known as carding or clothing wools. In the process of grading they are further divided into the following subgroups: Fine staple, strictly combing, baby combing, french combing, clothing, and stubby.

In one of the first processes of manufacture the fibers are put through a combing machine, which arranges them in parallel position and combs them together into a long ropelike strand which is

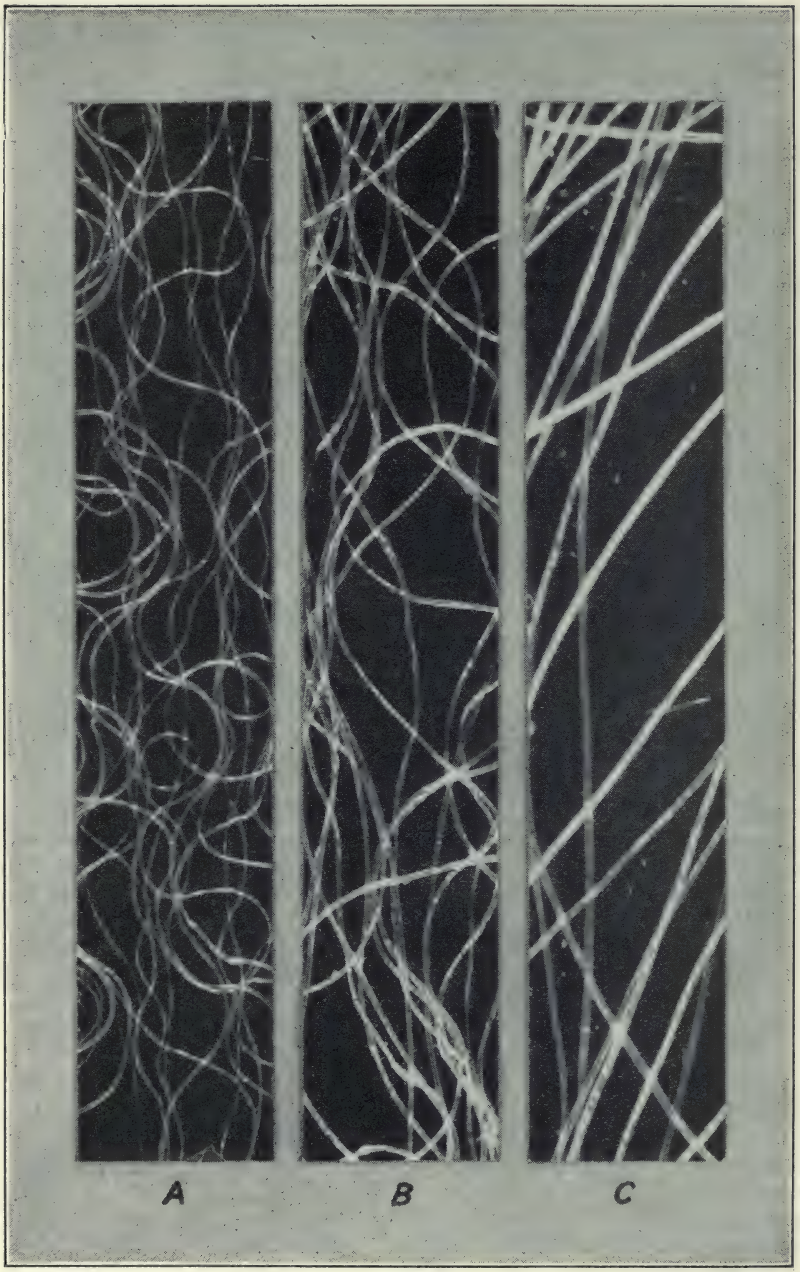

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FIGURE 5.—Typical wool fibers of different grades: *A*, Fine wool; *B*, Quarter-Blood wool; *C*, Braid wool. (Magnified.)

known as wool top (fig. 6). Carding or clothing wools are too short to be combed satisfactorily. Combing wools and the resulting tops are used especially in the manufacturing of all kinds of worsteds, which require relatively smooth, twisted yarns. There are two systems of worsted manufacture, the Bradford and the French. The former requires wool of long, sound staple. The latter can use staple that is as short as 1 inch, although it is not the general practice to use wools that do not have a length of at least 1¼ inches. Carding or clothing wools generally are carded and spun into soft, fuzzy yarns which are used chiefly in soft woven fabrics.

The natural color of wool is usually called white. It is not a pure white—in most cases it is really a cream color. The shade of cream color that a fleece acquires depends on whether the grease or yolk is of a light or dark color. Wool is said to be white when it is comparatively free from the darker tint.

White wools take the dye well in textile manufacturing. Dark-colored wools, ranging from gray to brown or black, are not so valuable as the white wools. A color defect which amounts almost to an impurity is the mixture of black fibers through a white fleece. Such a fleece cannot be sold as white wool; it cannot be used in the manufacture of white fabrics because the black fibers will show in white fabrics or those that are dyed a light shade.

The other characters of wool already mentioned play their part in making it of value for the manufacture of a given fabric. Strength, elasticity, crimp, and softness are all taken into consideration. The working property of wool is important, and good wool is that which can be carded, combed, spun, felted, woven, and knitted without undue loss or waste.

Wool that has been exposed to the weather until it is rough and dry and tangled by the wind is likely to waste in manufacture and is deficient in good working properties.

GRADES

Ordinarily wool, as it comes from the sheep's back, contains a large quantity of natural grease, dried perspiration, soil, sand, vegetable matter, etc. In this condition it is known as grease wool or wool in the grease (fig. 7). This foreign matter must be removed before the wool can enter the manufacturing processes. This is usually done by scouring the greasy wool in a water with a soap and soda solution. If the wool contains an excess quantity of vegetable matter it must be cleansed by being carbonized.

Wool in the grease is the ordinary raw wool bought and sold in commerce the world around. In this country the ordinary course of marketing is for the fleece to be sold by the grower to a local dealer or to be consigned to a commission dealer in one of the large cities; in certain instances it is sold directly to the manufacturer. Some 35 to 40 million pounds of wool are marketed annually through cooperative associations, which sell it chiefly to manufacturers.

Wool is unlike most other important agricultural commodities produced in this country in that there is no established public market for it. Although from 550,000,000 to 650,000,000 pounds of wool, with a total value of from $150,000,000 to $300,000,000, are handled

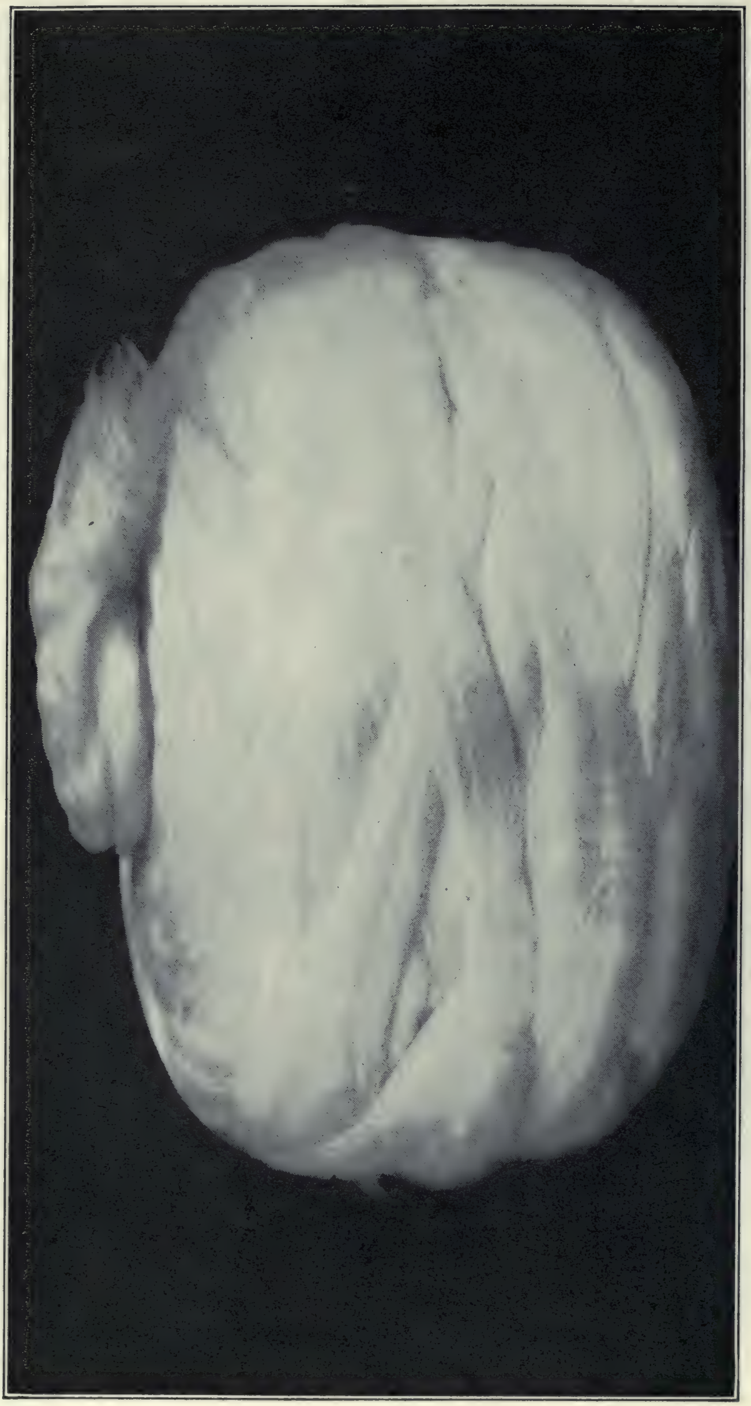

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FIGURE 6.—A ball of top. This ropelike strand is composed of only the longer fibers, which have been arranged parallel by the combing operation.

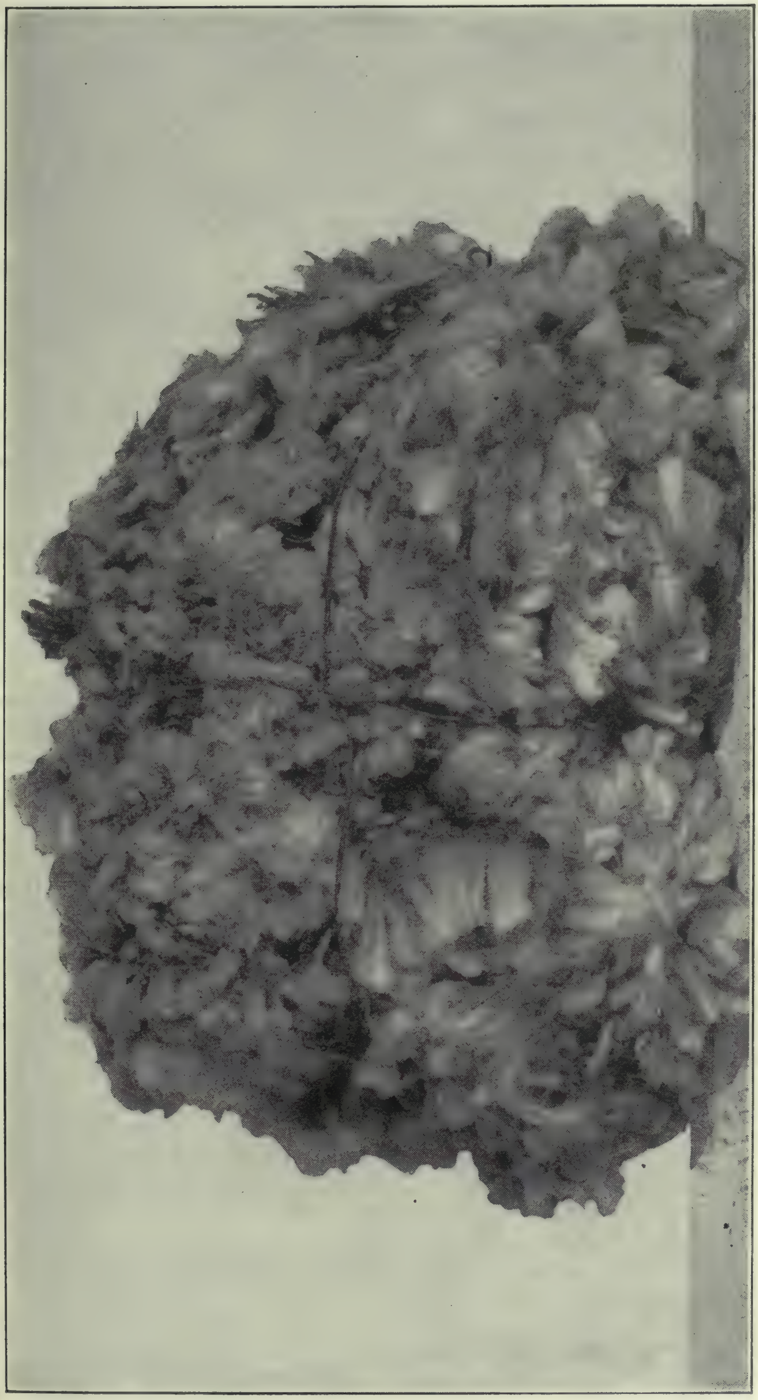

FIGURE 7.—Grease wool, greasy wool, or wool in the grease. Wool as shorn from a sheep.

annually in this country, there is no public market where it may be traded in as cotton, wheat, and other farm products are sold. Practically all of it is bought and sold privately, and a large part is merchandized through only a few central markets. The marketing of wool is more concentrated than the marketing of many other important farm products.

When the raw wool is assembled by a dealer, say, in Boston or some other market center, it is graded. Manufacturers of various fabrics wish to buy raw wool of certain grades that meet their particular needs.

Some clips, notably those from Texas, are so uniform that they are sold in the original bags, and manufacturers are glad to buy such wools as they come from the producer (fig. 8). The great bulk of wool, however, is graded by the dealers or cooperative marketing associations before it is sold to the manufacturers.

Grading is done by experienced men who can tell by the looks and feel of the wool how to grade it. They separate it into groups or piles having the greatest possible uniformity in fineness and other characteristics. It is this grading process which makes it possible for the manufacturers to buy wool suited to their individual needs; it also makes it possible to quote commercial market grades in terms that can be understood by the entire trade.

The grading system that has been long used in this country is the so-called "blood system." Presumably this originated in the early days of the sheep industry when the Merino was the fine-wool sheep on American farms. Merino wool was called Fine. All other wools were ranked according to their relative degrees of coarseness as compared with Merino. Presumably the terms used to designate the wool originally indicated the fractional quantities of Merino blood in the sheep that grew the wool of those types.

Whatever their origin, the grades that were developed were, and are now, called blood grades (fig. 9). In this American system seven grades are commonly now used. Five of them reflect the blood method of determination. They are: Fine, Half Blood, Three-eighths Blood, Quarter Blood, and Low-quarter Blood. The two coarsest grades now in use are Common and Braid, which apparently have no relation to the blood system.

The grade names as now used do not hold their original significance, for many wools of Half Blood, Three-eighths Blood, Quarter Blood, etc., are shorn from sheep that may or may not contain any trace of Merino blood. Fine-grade wool is grown today by Merino and Rambouillet sheep. Half Blood grade is grown by sheep having considerable Merino and Rambouillet blood. The next two grades, Three-eighths and Quarter Blood, come from Southdowns, Shropshires, Hampshires, Dorset, Cheviot, and Oxford. Low-quarter Blood, the next-lower grade of wool, comes largely from Oxford and some of the coarse-wool breeds. Common is the next-lower grade, and Braid is the lowest and coarsest. Wool of these two grades comes largely from Lincolns, Leicesters, and Cotswolds.

The English system of grading uses a numerical scale in which the finest wool is designated as 80's and the coarsest wool as 36's. Theoretically the numerals used to designate these grades signify the spinning capacity of wool that has been carefully selected for this

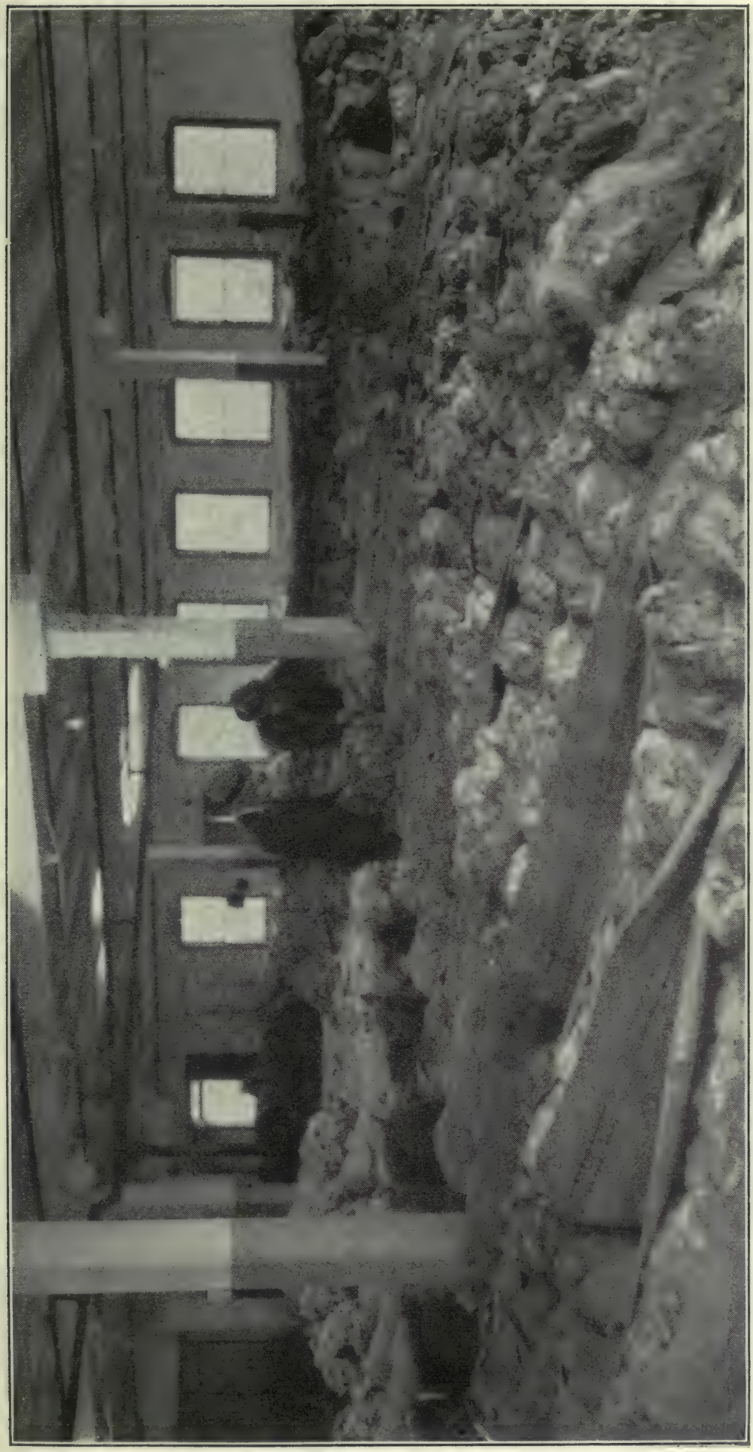

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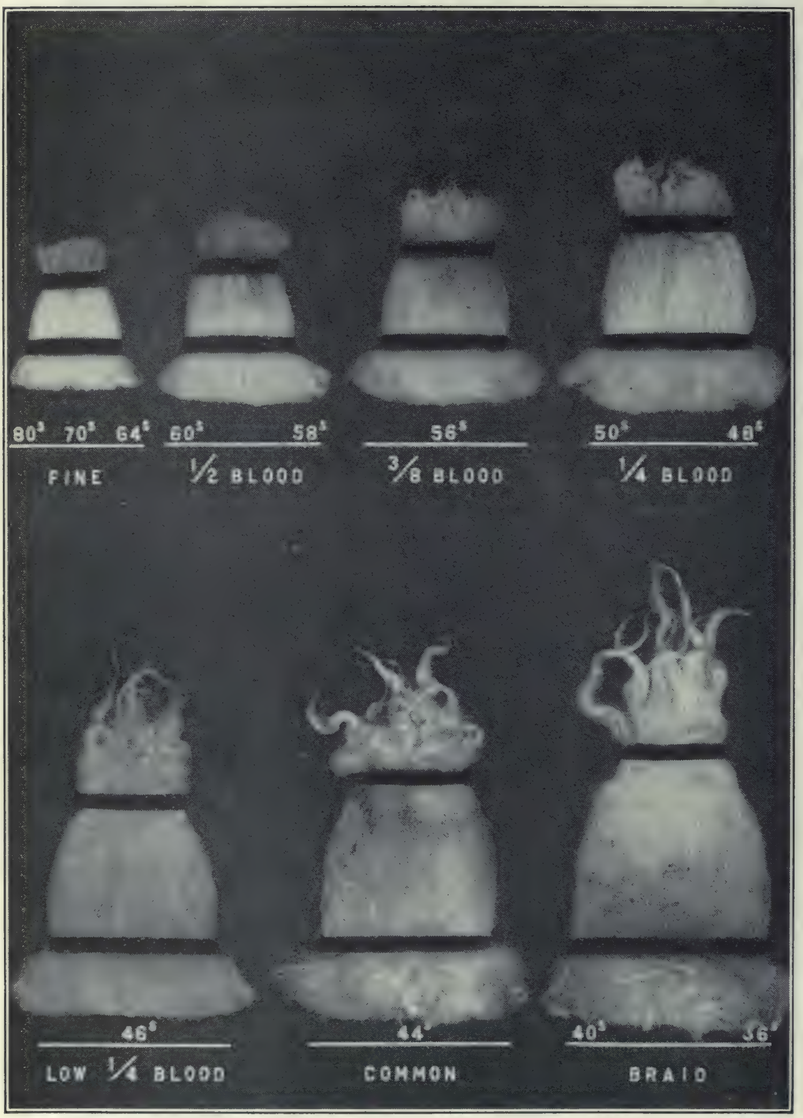
FIGURE 8.—Original bag wools being examined by a prospective buyer.


80s 70s 64s
FINE
60s 58s
½ BLOOD
56s
⅜ BLOOD
50s 48s
¼ BLOOD
46s
LOW ¼ BLOOD
44s
COMMON
40s 36s
BRAID

BAE 27916

FIGURE 9.—Grades of wool as represented in the practical forms of the official standards for grades of wool are designated by the blood terms as well as by the corresponding numerical terms.

purpose. For example, a 60's grade of wool when processed and spun to capacity would result in 60 standard hanks of yarn which would weigh approximately 1 pound, and 80's grade of wool would make 80 hanks, etc. The numerical system of grading is in general use not only in England but throughout the world in the international wool trade.

The following list gives a fair idea of the corresponding grades in the American and English systems:

American:	English:
Fine.	80's, 70's, 64's.
Half Blood.	60's, 58's.
Three-eighths Blood.	56's.
Quarter Blood.	50's, 48's.
Low-quarter Blood.	46's.
Common.	44's.
Braid.	40's, 36's.

Not only does one fleece contain more than one grade of wool, because of the variations in the diameter of the fibers, but often there are variations in diameter from the base to the tip of the fibers (fig. 10). The wool grader must be able to detect these variations and decide within what limits they will fall before he can grade the wool with reasonable accuracy. As a rule the work of the experienced grader is exact enough to satisfy buyers and sellers.

Satisfactory grading requires training, skill, and careful judgment on the part of the grader. As there is no mechanical device suitable for rapid measurement of the diameter of the fibers, the grades are determined by sight and touch (fig. 11).

A good light is essential to correct grading. Northern daylight is best, without either direct sunlight or artificial light. Under too strong light the fibers are likely to appear distorted and irregular, and the essential thing in grading is to differentiate readily between diameters.

In grading wool more attention is generally given to the diameter of the fibers than to the other factors. However, these other factors affect the value of the wool and must be given due consideration. No grading is complete until the wool has been judged according to such factors as the condition of the fleece, length of staple, and strength and character of the fibers. Shrinkage (loss in scouring) is not a grade factor, but it is highly important when the value of the grease wool is being appraised.

CLASSIFICATION OF WOOL BY REGIONS

In market practice the trade freely identifies wools with the States or regions in which they were grown because the character and appearance of the wool often are affected by conditions in those areas. At least four major regions of the United States so affect the character of the wools grown therein as to distinguish them from wools grown in other regions. Grease wools grown in these different regions differ in condition, shrinkage properties, and color because of differences in soil, in grazing and climatic conditions, and in husbandry practices.

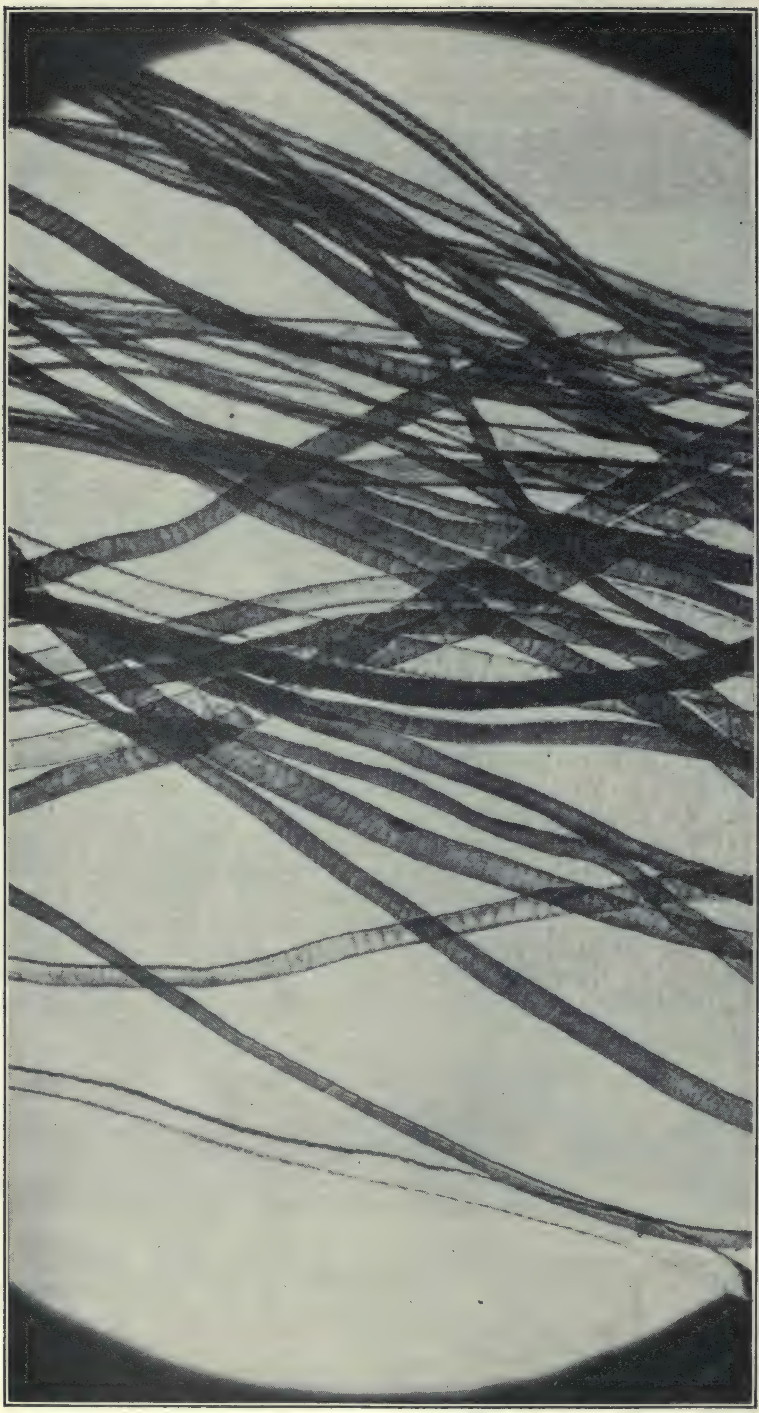


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FIGURE 10.—Wool fibers showing variations in diameter. (Magnified.)

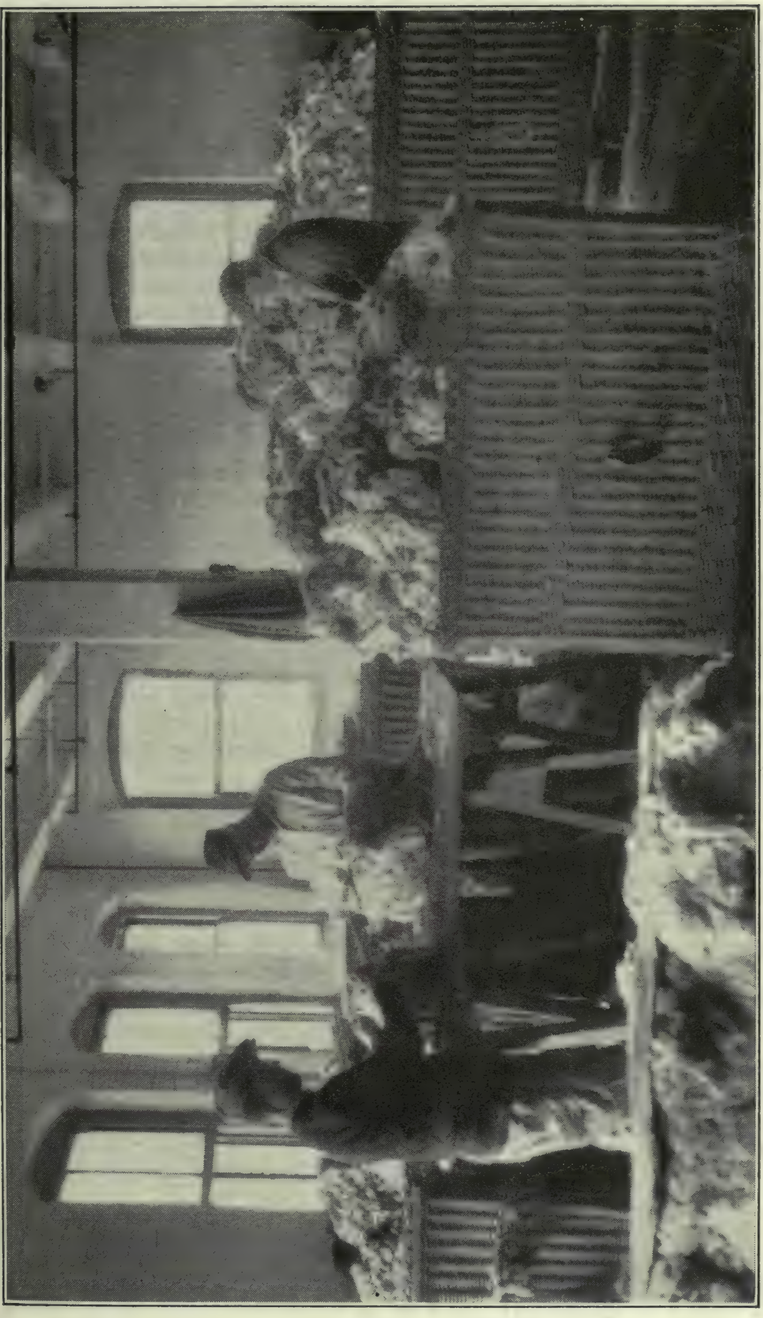

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FIGURE 11.—Grading wool.

These variations often affect materially the market values of the grease wools, even of the same grade. In recognition of this fact, the wool trade has broadly classified domestic wools into four general groups based on areas of production, as follows: Territory wool, semibright wool, bright wool, and southern wool.

TERRITORY WOOL

That part of the domestic clip produced west of the one hundredth meridian is known in the trade as territory wool and is produced in the States of Washington, Montana, Idaho, Wyoming, Nevada, Utah, and Colorado, in the western halves of North Dakota and South Dakota, and occasionally in western Kansas and Nebraska.

Sheep in the "territory" States graze over wide areas and are subject to widely varying soil, climatic, and grazing conditions, and usually are without protection from the weather. All of this affects the quality and shrinkage properties of wools.

Wools grown in Texas, California, and Oregon are generally known by the name of the State in which they are produced. Arizona and New Mexico wools also are generally classed separately because wools from these States have peculiarities that distinguish them from wools from other States and regions.

SEMIBRIGHT WOOL

Wools produced in Oklahoma, in the eastern parts of Kansas, Nebraska, South Dakota, and North Dakota, and in parts of Missouri, Iowa, Minnesota, and Wisconsin have a dark or stained color caused by deposits in the fleeces of bits of the soil. The fleeces thus affected appear dirty and unattractive, but they scour out white.

Semibright wools often are grouped and graded with territory or with bright wools, according to their predominating characteristics.

BRIGHT WOOL

Bright wools are produced in the States east of the territory and semibright areas, extending to the Atlantic seaboard. These wools are less exposed to colored soils and other foreign matter than are those in various western areas, so the fleeces are much cleaner and brighter. Such wools have fairly uniform shrinkage, whereas wools from the semibright and territory regions have widely varying shrinkages.

SOUTHERN WOOL

Wools grown in the Southeastern States are of bright color and in this respect are similar to bright wools produced in the States east of the territory and semibright regions, but they are designated by the trade as southern wools. Many so-called southern wools are inclined to be brashy, run-out, and uneven, as they are shorn from sheep belonging to no particular breed or class.

In some of the Southern States, however, especially in Kentucky, Virginia, and Tennessee, where better strains of sheep are raised, some choice wools are produced that grade Three-eighths and Quarter blood. Very little wool of the Fine grade is produced in the Southeastern States.

"OFF" WOOLS

"Off" wools are defective fleeces; they are otherwise known as discounts, rejections, or unmerchantable wools. Among the wools that are generally classified by the trade as off wools are fleeces in the following conditions: Burry, seedy, chaffy, cotted, black and gray, dead and murrain or merrin, and tags (fig. 12).

Burry, seedy, and chaffy are descriptions applied to wool which has excessive quantities of burs, seeds, chaff, or other vegetable matter entangled in the fibers. When this condition exists additional chemical or mechanical treatment is necessary.

Cotted fleeces are those in which the fibers have become badly tangled or matted. "Hard cots" or "soft cots" are terms denoting the degree of tangle or mat in the fibers. (The English form is cotts.) Special mechanical treatment is usually necessary to open these fleeces when preparing them for the manufacturing processes.

Black and gray are the terms used in the market to describe colored wools. The first is usually applied to that which is nearly all black, and colored fleeces containing relatively large quantities of white, brown, or gray wool are designated by the last term.

Dead wool is wool that has been clipped from sheep shortly after their death. When wool is recovered from decomposed remains found on the ranges, it is designated by the term "murrain" or "merrin."

Tags are parts of the fleece heavily matted with dung and other animal or vegetable impurities. The term "tag locks" is sometimes applied to such discount wool.

Off wools are always of inferior quality, and the quality of many of them is further impaired by the severe cleaning processes necessary to put them in usable condition.

WOOL GRADING AND THE FARMER

A knowledge of grading is of value to the wool producer in at least three ways. (1) It enables him to understand the current market quotations, for prices are quoted ordinarily according to commercial grades. (2) It tends to put the grower on a more even footing with the buyer (who is always inclined to protect himself in his estimate of shrinkage) in regard to the percentage that the clip will run by grade and the proportion of black, burry, and seedy wool present. (3) An accurate knowledge of grades serves as an excellent check on any deterioration of a grower's fleeces or band. It becomes a guide for breeding operations with respect to either individuals or the entire flock.

Grading wool means grouping individual fleeces according to a definite type. The degree of fineness of wool, based on diameter of fiber, is the most important single consideration; it affects materially the products made from the wool and therefore the value of the wool.

Wool manufacturers generally require and buy only specific grades of wool for their individual needs. Although the wool is often graded more closely to suit the special needs of certain manufacturers, the ordinary practice is to grade it in accordance with general mill requirements. During the process the fleeces are put in groups or piles which will be reasonably uniform in all the essential characteristics of each fleece. These units or piles are called graded fleeces (fig. 13).

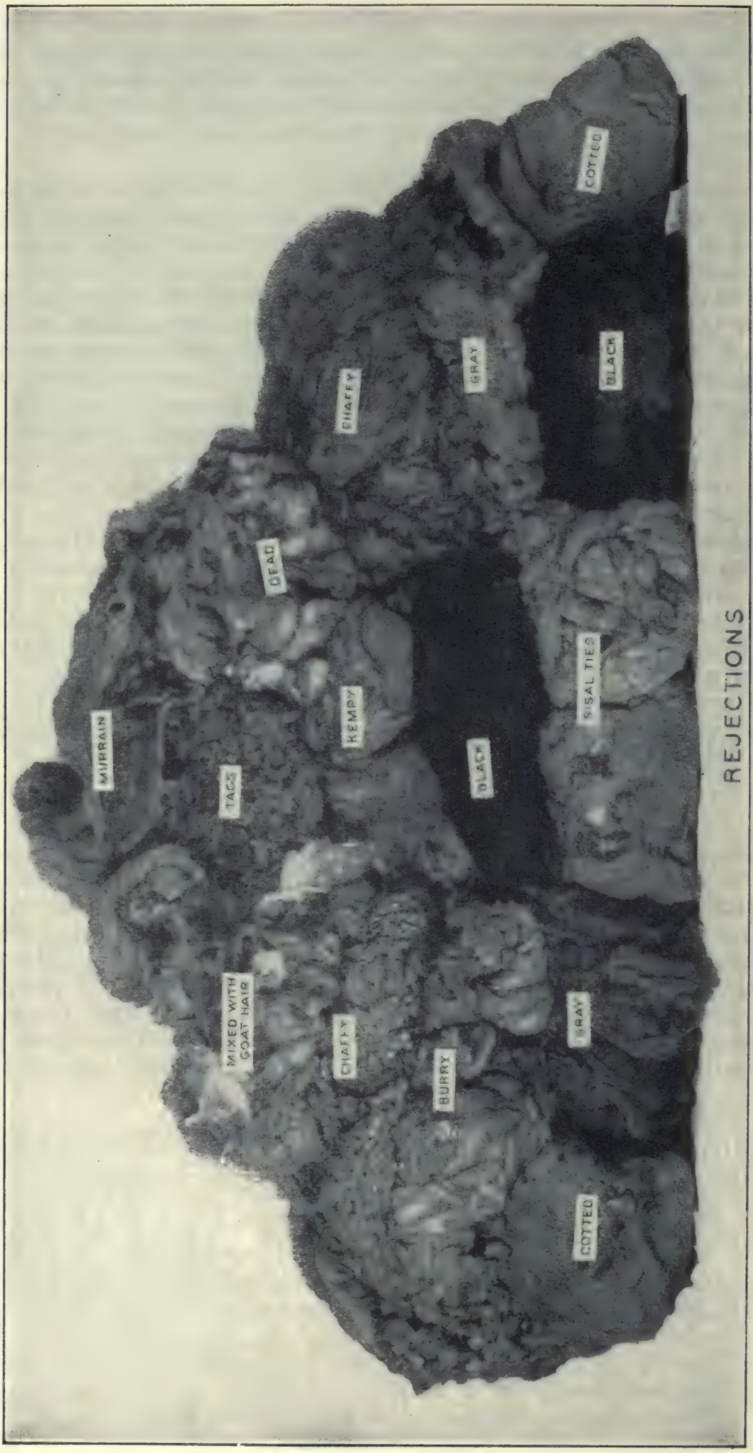

COTTED
BLACK
GRAY
CHAFFY
DEAD
SISAL TIES
KEMPY
BLACK
MURRAIN
TAGS
MIXED WITH GOAT HAIR
CHAFFY
BURRY
GRAY
COTTED
REJECTIONS
EAE 25527

FIGURE 12.—Off wools—discounts, rejections, or unmerchantable fleeces.

BAE 18289

FIGURE 13.—A pile of graded Three-eighths Blood combing fleeces.

The grading of wool, as now practiced, is a process that can be learned accurately only through visual demonstration and through experience. It demands trained judgment in respect to qualities, and quality must be ascertained by the actual look and feel of the wool.

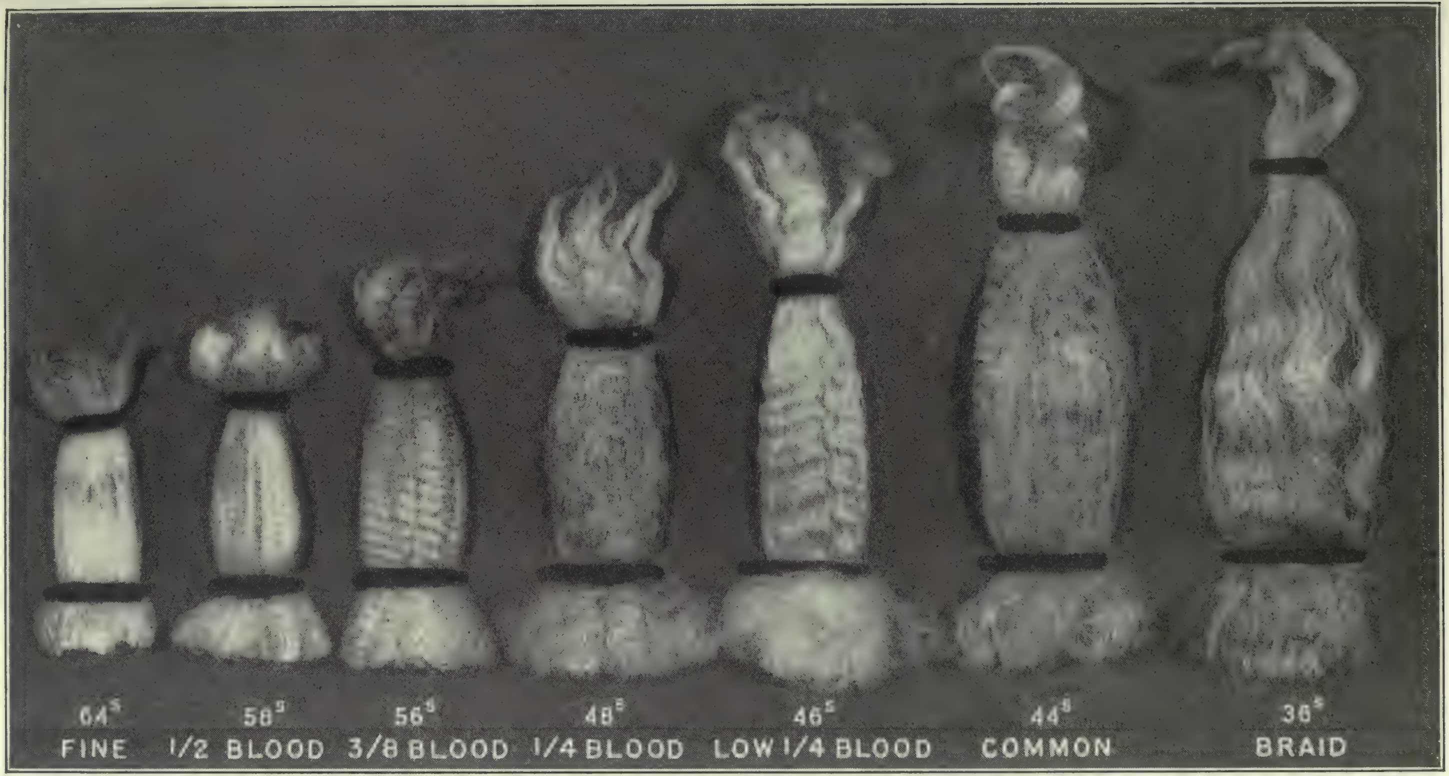
Accordingly, this bulletin must be limited to explanations and cannot be expected to tell the farmer exactly how to grade his wool; but the fact remains that some practical knowledge of wool grades is decidedly useful to one having any considerable quantity of wool to sell. Few growers are familiar enough with the grades of wool to get full information regarding the value of their wool from market quotations. Those who are reasonably familiar with the characteristics that make for value are in better position to interpret quotations and to market their clips advantageously.

Whether the grading of wool at the source, at time of shearing, will or can become a universal practice is a question that cannot be answered here. There are reasons why it would be advantageous to growers; but a very much larger number of skilled graders would be required than are now available. Wool badly graded never will be acceptable in the channels of trade; commercial grading is, after all, a job for trained and experienced men. If grading at the point of origin does become a general practice, the use of a single standard for grades of wool will be necessary in order that wool in each grade may be uniform and that more confidence in such grades may be established.

There is general agreement among wool men that it is desirable to make at least some division in fleeces in respect to grade, at the time of shearing. There is, however, no agreement concerning the closeness with which the grading should be done or the number of grades that should be used. Some think that merely a separation should be made of the rejections, such as the black and the burry fleeces, the dead and the cotted wool, the tags, etc. Others think that the wool should be graded at the shearing pen into the grades that are used in the market centers. It is doubtful whether a sufficient number of experienced graders are available to make that plan feasible as yet. On the other hand, the mere separation of the "off" fleeces from the good would not accomplish the end of having the wool so put up as to permit more ready appraisal by grade. Probably there is an intermediate point to which the grading of the wool at the source can be carried with prospects of higher net returns to growers.

The Bureau of Agricultural Economics has prepared a wool-grade chart (fig. 14) on which seven samples represent the different grades of domestic grease wools, arranged according to their relative fiber diameters. Each sample indicates as nearly as possible the maximum diameter of fiber allowed in its "Blood" grade when taking into account the other factors that influence grade.

This wool-grade chart will be sent on request by the Bureau of Agricultural Economics, Washington, D. C., to vocational instructors, agricultural leaders, and county agents who wish to illustrate the grades of wool.


64^s
FINE
58^s
1/2 BLOOD
56^s
3/8 BLOOD
48^s
1/4 BLOOD
46^s
LOW 1/4 BLOOD
44^s
COMMON
36^s
BRAID

BAE 22192

FIGURE 14.—School chart showing samples of the different grades of wool. (Approximation of grades in the official standards for grades of wool.)

One who wishes to make a practical application of the grades illustrated on the chart may do so by comparing staples drawn from fleeces with the samples shown on the chart. He should place the fleece staple that is to be matched with the chart on a black cloth or cardboard in ordinary daylight (not sunlight). He should spread the fibers apart and examine their fineness. He should also become familiar with the comparative feel of the staples in his fleece samples and those on the chart. He may learn to associate the fiber of a certain thickness with the appropriate grade name. Students have found that measuring the thickness of the individual fibers with a micrometer caliper is helpful when learning to distinguish fineness.

After considerable practice it should be possible to pick out staples from ungraded fleeces and identify them readily as Three-eighths Blood or Low-quarter Blood or Common or Braid.

Fineness or diameter of fiber is the first and most important characteristic. Recognition of this property of wool cannot be taught on paper. A man can become familiar with the different grades only by personal study of actual wool samples.

Once a person has a fairly good idea of the different degrees of fineness, he can examine a fleece, either shorn or on the back of the sheep, and say with some degree of assurance, "This wool will grade Half Blood" or "Quarter Blood," as the case may be. In time, and with sufficient experience of this kind, he can gain a fairly good idea as to how his wool will grade, at least within practical limits.

After the matter of fineness, the next major consideration is the length of staple. Take a fleece, either shorn or on the sheep's back; spread apart the staple; and examine it for length. Graders have a way of taking hold of the end of a staple with thumb and finger and drawing it back over the thumb of the other hand so that its full length lies along the thumb. If the staple reaches to or beyond the second joint, the old "rule of thumb" is that it is combing wool. If it is shorter than this, it is clothing wool, or possibly the length may lie between these two in a class called French combing. Combing wool is that with a staple 2 inches long or more. Clothing wool has a staple under 1¼ inches in length. As all wool producers know, the long-staple combing wools bring more money in the market than do the short wools. A knowledge of the worth of his fleeces, if they are of high quality, should mean more money to the grower.

Besides fineness and length of staple, there are, of course, various other factors that affect the value of the fleece. Its color and general condition count for something in terms of price because it is on these things that the buyer forms his judgment as to the probable shrinkage of the wool. Wool that is full of sand, dirt, and various kinds of vegetable matter will have a high percentage of shrinkage, and the buyer will scale down the price he pays enough to protect himself against this shrinkage. On the other hand, the wool may be in very good condition, with the probability of a minimum of shrinkage; in that case it is up to the grower to back his position at the time of sale with a knowledge of the good properties of his wool.

Probable shrinkage is something that cannot be taught on paper or even by a single visual demonstration. It is one of those elements in judging wool that can be gaged only after experience and on the basis of a fairly broad knowledge of all the characteristics of raw wool.

It is a thoroughly practical thing for any wool producer to take the steps here suggested. He can get sample staples, familiarize himself with the degrees of fineness and staple length that go with each of the seven grades, and thus learn a great deal about the quality of his wool. If this is followed up by attending grading demonstrations such as are held from time to time throughout the wool-growing sections, he can become proficient enough in grading so that he will not be at any serious disadvantage in the wool market. Many large producers are finding it worth their while to learn to grade wool in the only way it can be learned accurately—that is, from an experienced grader.

OFFICIAL STANDARDS FOR GRADES OF WOOL

Producers and others agree that there should be a greater degree of standardization than now prevails in the grades used in marketing wool. Such standards provide a common language for producers and the trade, which will tend ultimately to stabilize the wool market and provide a basis for the dissemination of reasonably accurate market information.

To meet this need, the Bureau of Agricultural Economics has developed the seven grades of domestic wool, ranging from Fine to Braid, which were established some years ago as the official standards of the United States for use in merchandising wool. There is nothing compulsory about these standards. Their use is voluntary or permissive.

The official type samples which were established to illustrate these grades show as nearly as possible the maximum and the typical diameters of fibers permissible in a given grade of domestic wool. In recognition of the established custom in this country, the blood system of terminology is used in these standards to designate the seven grades (fig. 9). They are applicable in grading fleeces at shearing pens and at central markets.

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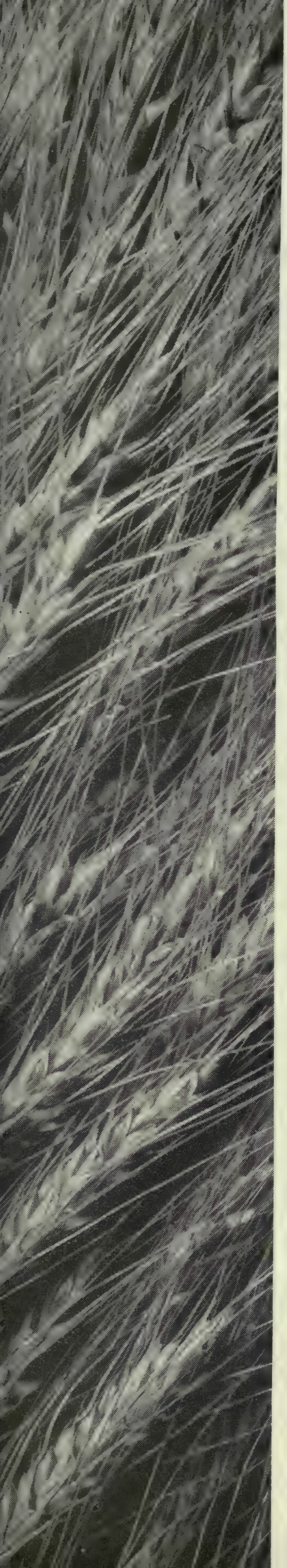

HARD RED WINTER WHEAT VARIETIES

FARMERS' BULLETIN
No. 1806
U.S. DEPARTMENT
OF AGRICULTURE

HARD RED WINTER WHEAT is grown principally in the central and southern Great Plains area, where hot summers and rather severe, dry winters prevail. Kansas, Texas, Oklahoma, and Nebraska lead in the production of hard red winter wheat. More than 27 million acres are grown annually in the United States, comprising nearly one-half of the total wheat acreage.

Thirty-four varieties are grown commercially in the United States and these are known under many different names. Of these, the leading varieties are Turkey, Kharkof, Blackhull, Kanred, and Nebraska No. 60. Turkey and Kharkof are nearly identical and, prior to the wide distribution of Blackhull, Kanred, and other newer varieties, made up nearly all of the hard winter wheat acreage.

Blackhull has proved to be a high-yielding variety in southern Kansas, Oklahoma, and the Panhandle of Texas, principally because of its earlier maturity, vigorous growth, and stiff straw. It now ranks next to Turkey in total acreage.

Kanred has been grown commercially during the last 20 years, and for a time exceeded Blackhull in acreage. It is resistant to some of the forms of leaf rust and stem rust that occur in the hard winter wheat area. It is slightly more winter hardy than Turkey, ripens a few days earlier, and outyields it in most sections.

Tenmarq, an early, high-quality wheat, has given good yields in southern Kansas, Oklahoma, and Texas. Minturki has outyielded other hard red winter wheats in Minnesota because of its winter hardiness. Early Blackhull has gained some popularity in south-central Kansas because of its extreme earliness, but it is not sufficiently winter hardy to be grown with safety. Cheyenne, a stiff-strawed, erect-headed, high-yielding variety, is increasing in popularity in Nebraska.

Among the beardless varieties, Ridit is most extensively grown. It is popular in Washington because it is resistant to some forms of bunt and because it has stiff straw and is nonshattering. Other beardless varieties are Michikof, in Indiana and Illinois; Newturk in Montana; and Mosida in Idaho.

This bulletin is a revision of and supersedes Farmers' Bulletin No. 1585, Varieties of Hard Red Winter Wheat.

Washington, D. C. Issued December 1938

HARD RED WINTER WHEAT VARIETIES[1]

By K. S. QUISENBERRY, *agronomist*, and J. ALLEN CLARK, *senior agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry*

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THE HARD RED WINTER CLASS OF WHEAT

THE HARD RED WINTER WHEATS make up the largest and, in many respects, the most important commercial class of wheat in the United States. More than 27,000,000 acres, or nearly half of the total wheat acreage in the United States, was occupied by this class of wheat in 1934. The varieties of the class are among the most winter hardy and drought- and heat-resistant of any grown in the world. With the possible exception of the hard red spring wheats, they also have the highest protein content and are among the best for bread making. The grain is also used extensively for blending with softer varieties and wheats of low protein content.

The original seed of the hard red winter wheats was introduced from Russia in 1873. Many varieties have been brought in from Russia and other foreign countries since that time, and a number have been produced in the United States by selection and hybridization. Some of these are very similar and cannot be distinguished from each other by their outward appearances. Most of them are bearded and have white glumes, hard red kernels, and rather weak straw. Largely because of their winter hardiness, drought resistance, and early maturity they are able to produce fairly high yields under the extremely variable climatic conditions of the Great Plains.

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[1] The information given in this bulletin is based on (1) varietal experiments conducted by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the State agricultural experiment stations, either independently or in cooperation; (2) classification studies of all American wheat varieties; (3) surveys of the wheat varieties of the United States in cooperation with the Bureau of Agricultural Economics, based on returns from questionnaires sent to crop correspondents at 5-year intervals; (4) several years of personal observations of the wheatfields in the States where these varieties are grown; and (5) milling and baking experiments conducted by the Division of Cereal Crops and Diseases in the Milling, Baking, and Chemical Laboratory of the Bureau of Agricultural Economics, in cooperation with State agricultural experiment stations.

AREAS TO WHICH HARD RED WINTER WHEATS ARE ADAPTED

The hard red winter wheats are best adapted to the central and southern sections of the Great Plains, where the annual rainfall is less than 35 inches. The States leading in production are Kansas Nebraska, Texas, and Oklahoma (fig. 1). In this region there is little competition with other classes of wheat. Eastward, where there is a higher annual rainfall, they come into competition with the soft red winter wheats. In eastern Kansas and Oklahoma and northern Missouri, where the annual rainfall varies from 35 to 40 inches, they are found mostly on the higher, drier, and less fertile soils, whereas the soft wheats occupy the lower, more productive soils where lodging is quite likely to occur. The hard red winter wheats are also grown to a considerable extent in northern Illinois and northwestern Indiana because of their greater winter hardiness as compared with other classes. They are also grown in some of the drier sections of Oregon, Washington, and Idaho, where the annual rainfall is approximately 15 inches. A relatively small acreage is grown in Minnesota, South Dakota, Wyoming, and Montana, since the hard winter wheats are practically the only winter wheats that will survive the extreme winter temperatures of those States. In recent years the acreage of winter wheat in these northern areas has tended to increase somewhat because of the development of more winter-hardy varieties and better methods of growing them. In most parts of the latter group of States spring wheats are more important.

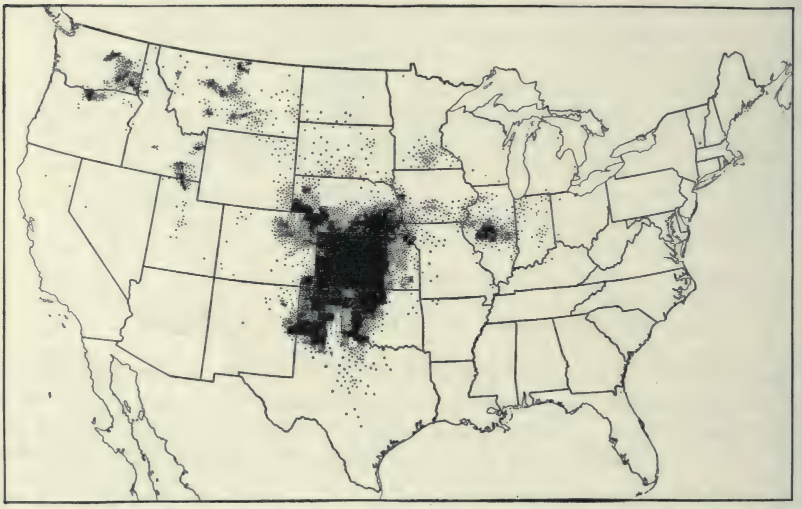


FIGURE 1.—Distribution of hard red winter wheat in 1934. Each dot represents 2,000 acres. Estimated area, 27,170,453 acres.

VARIETIES AND DISTINGUISHING CHARACTERS

The number of distinct varieties of hard red winter wheat grown in the United States has gradually increased from a single variety in 1873 to 34 in 1937. Some of these have been introduced from foreign countries, especially Russia (the Union of Soviet Socialist Republics), and others have been produced in the United States by selection and breeding. During the last 30 years thousands of selections and hybrid strains have been tested at agricultural experiment stations throughout the area, but only a few of the best have been named and increased for distribution. The varieties are known under a large number of names. Their identification is often difficult, since only a few can be definitely identified by external characters. However, some of those which appear to be the same, really differ with respect to their adaptation to climatic conditions and resistance to disease, or in such characters as winter hardiness, drought resistance, and yield. Since the ability to survive and to produce a high yield of good quality of grain can be determined only by growing a variety for a number of years, new varieties should not be grown extensively until they have been thoroughly tested.

For convenience in discussion, the varieties of hard red winter wheat are divided into two groups on the basis of head characters: (1) Those that have beards or awns and (2) those that do not.

GROUP 1.—HEADS BEARDED

Group 1 is by far the most important, both with respect to number of varieties and acreage. All varieties of this group have bearded heads, with glabrous (not velvety) chaff and hard, dark-red kernels. They are sometimes referred to as the Crimean group of hard red winter wheat. Most of them have white chaff, but some have black chaff under certain conditions; others have brown chaff; and a few have yellowish chaff with brown stripes. The plants are of medium height and, with one or two exceptions, have slender stems which lodge easily in wet seasons. The leaves are dark green and rather narrow. The heads are about 3 to 3½ inches long and rather narrow and tapering. The chaff usually is sufficiently firm to prevent loss from shattering. The grain differs from that of hard spring wheat in having greater length, rounded edges, and a smaller area of the germ or embryo, and from that of soft winter wheats in having smaller, harder grain. Most of the varieties ripen medium early and are winter hardy. The principal varieties of this group are: Turkey, Kharkof, Blackhull, Kanred, Nebraska No. 60, Tenmarq, Minturki, Superhard, Iobred, Karmont, Redhull, Early Blackhull, Cheyenne, Cooperatorka, Utah Kanred, Eagle Chief, Montana No. 36, Ioturk, Iowin, Ilred, Sherman, Oro, Ashkof, Wisconsin Pedigree No. 2, Nebraska No. 6, Ukrainka, Rio, Relief, and Yogo.

TURKEY

The most important variety of hard red winter wheat is Turkey (Turkey Red). It is known also by many other names, some of the more common being Alberta Red, Crimean, Defiance, Egyptian, Hard

Winter, Hundred and One, Improved Turkey, Malakof, Minnesot Red Cross, Minnesota Reliable, Pioneer Turkey, Red Russian, Re Winter, Russian, Ulta, and World Champion. Other names, such a Argentine, Bulgarian, Hungarian, Romanella, and Theiss, have bee applied to introductions of wheat apparently identical with Turke which are grown only experimentally. The variety as originall introduced and as now grown contains a number of strains. Som of these have been separated by plant or head selection and distrib uted as new varieties or improved varieties.

Turkey has the general characteristics of the varieties of th Crimean group. The heads are bearded, the chaff is white, and th grains are hard and dark red. The "beaks" (short beards on the oute chaff) are about one-eighth to three-eighths of an inch long (fig 2, *A*). As in other varieties of this group, the straw is rather wea and inclined to lodge when grown on fertile soil in areas of hig rainfall. Turkey is comparatively winter hardy and drought resistant. It is also more resistant to bunt or stinking smut than ar certain other varieties, especially some of those grown in the Pacifi Northwest.

Turkey wheat was introduced into the United States by Mennonit immigrants from Russia about 1873. Its original home is just nort and east of the Black Sea and north of the Caucasus Mountains in th Union of Soviet Socialist Republics, where soil and climatic condi tions are very similar to those in the southern Great Plains. I was first grown in this country in Kansas and Nebraska. At firs it was discriminated against by millers because of its hard grai and the difficulties encountered in milling it. After the steel-rolle mills were perfected, these objections ceased, and its acreage increase rapidly. Today it is the most widely grown variety in the Unite States. More than 15,000,000 acres of Turkey wheat were grown i 28 States in 1934. The distribution is shown in figure 3. In 193 about 5,500,000 acres were grown in Kansas; 2,000,000 acres in Texas 1,900,000 acres in Nebraska; and 1,500,000 acres in Oklahoma. Th wide adaptation of the variety is emphasized by the fact that it i recommended by the agricultural experiment stations of 14 States Turkey is best adapted to the areas shown in solid black on the ma (fig. 3). Until the recent distribution of a number of new varietie it was regarded as the highest yielding variety for most of this area It is still considered as among the best. It is also considered th best variety north and west of the area of heavy production of har red winter wheat, in Wyoming and South Dakota and in certain sec tions of North Dakota and Montana. In the more humid portions o the hard red winter wheat belt, as in northern Missouri, northeaster Kansas, southern Iowa, and central Illinois in which both hard an soft red winter wheats are grown, the value of Turkey in compariso with other varieties depends on the soil, elevation, rainfall, an seasonal and local conditions. In general, several varieties of sof or semihard red winter wheat are equal to or better than Turkey i this area.

Turkey is a high-yielding variety in southeastern Idaho and th adjoining section of Utah and is well adapted to the western part o the Columbia River basin of Oregon and to the drier portions o eastern Washington. In the latter section it is not so susceptible t

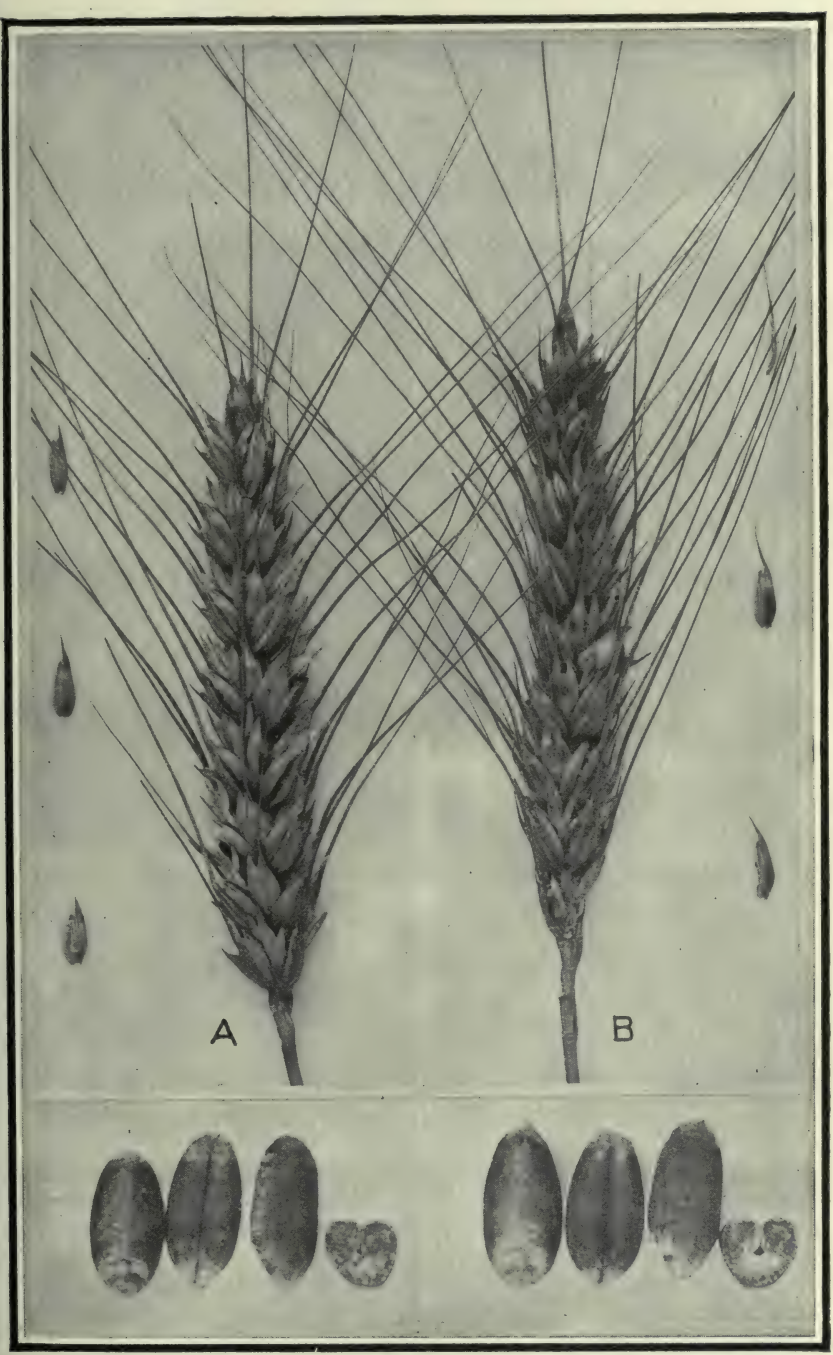


FIGURE 2.—Turkey (*A*) and Kanred (*B*) varieties of hard red winter wheat.

bunt or stinking smut as some of the club and soft red winter wheat commonly grown.

The name Kharkof is applied to an introduction of Crimean whea brought to this country from Starobielsk, Kharkof, Russia, in 1900 by the late Mark Alfred Carleton, of the United States Departmen of Agriculture. This section of the Union of Soviet Socialist Re publics is north of that in which Turkey wheat was grown, and con sequently it was thought that Kharkof would be more winter hard than Turkey. In the earlier experiments it gave better yields tha Turkey, but in recent years very little difference in hardiness o yield has been observed. The variety was widely distributed by th Department of Agriculture and several State agricultural experimen stations in the early years of the present century. Since Kharkof i general cannot be distinguished from Turkey by any observabl characteristics and since it does not differ from Turkey in winte hardiness, yield, or quality it should properly be considered as identi cal with that variety. It is grown in the same area as Turkey, an in recent years the two varieties usually have been considered as one

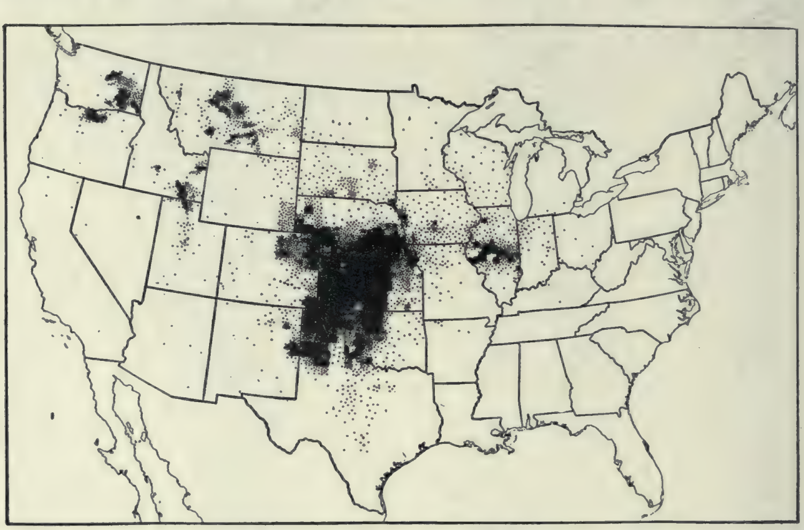


FIGURE 3.—Distribution of Turkey wheat in 1934. Each dot represents 1,000 acre Estimated area, 15,114,395 acres.

BLACKHULL

Blackhull (known also as Clark's Black-hulled and Black Chaff usually can be distinguished from Turkey by the black stripes o solid black color of the outer chaff. Under some conditions, howeve this black color does not develop, in which case the chaff is white Blackhull also differs from Turkey in being a little earlier and talle and in having slightly stiffer straw and somewhat larger and softe kernels. It heads relatively early but ripens only a few days earlie than Turkey, thus having a longer fruiting period. It is not resistan to rust or bunt, but its earliness may enable it to escape severe rus injury. It is decidedly less winter hardy than Turkey.

The variety originated from three heads found by Earl G. Clark in a field of Turkey wheat near Sedgwick, Harvey County, Kans., in 1912. These heads were grown separately, and the seed was increased by Mr. Clark and first distributed in 1917. Since that time it has become widely grown in the southern Great Plains area. In 1934 it was reported from 10 States, with a total of more than 6,000,000 acres, ranking second among the hard red winter wheat varieties. The distribution of the variety is shown in figure 4. The largest acreages of Blackhull are in Kansas (4,400,000 acres), Oklahoma (1,100,000 acres), and Texas (900,000 acres).

Blackhull has given yields equal to or better than those of Turkey in central and eastern Kansas but somewhat less in northwestern Kansas. It has replaced much of the Turkey in southern Kansas, Oklahoma, and the Texas Panhandle. In comparative experimental trials it has given good yields in northeastern Colorado and eastern Oregon. For a time it was grown commercially in central Illinois, but the acreage there is gradually decreasing. Owing to its lack of winter hardiness it should not be grown in sections having severe winters. It is probably safe to grow Blackhull from central Kansas southward, but north of this area there is danger of severe winter-killing and heavy losses. Because of a series of winters with very little winter-killing, Blackhull is now grown much farther north and west than is considered safe.

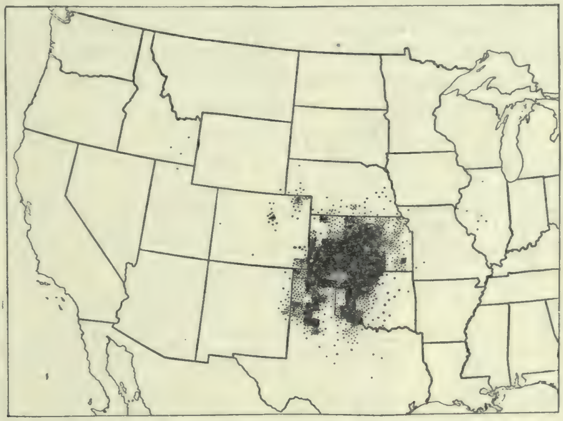


FIGURE 4.—Distribution of Blackhull wheat in 1934. Estimated area, 6,617,379 acres.

When Blackhull was first distributed there was some doubt as to its milling and baking quality. The Kansas Agricultural Experiment Station demonstrated that it was less tolerant to severe mixing than other hard winter wheats, and it seemed that this might limit its usefulness for commercial bakeries. In recent years the trade has learned how to use Blackhull, and the objections to it are neither so numerous nor so great as formerly. In the household the mixing of the dough is not severe, and for home baking Blackhull produces bread as satisfactory as that from Turkey or Kanred. In experimental trials Blackhull has a consistently heavier test weight than Turkey or Kanred but produces a lower percentage of straight flour for a given test weight.

SUPERHARD

Superhard (Super-hard Blackhull) is identical with Blackhull except that it has slightly harder kernels and is decidedly poorer in milling and baking quality. It is the result of a selection made from Blackhull by Earl G. Clark, Sedgwick, Kans., the originator of Blackhull, in 1920. The variety spread rather rapidly in south-central Kansas and in Oklahoma for a year or two, but it became mixed with Blackhull and its identity has been lost. The acreage at the present time probably is not large. The variety cannot be recommended in preference to Blackhull, and its production should be discouraged.

KANRED

Kanred differs from Turkey chiefly in being resistant to some forms of leaf and stem rust, especially in the seedling stage. It also is slightly earlier and a little more winter hardy than Turkey. Usually it can be distinguished from Turkey by the longer beaks on its outer chaff. These vary from one-eighth to 1 inch in length as compared with one-eighth to three-eighths of an inch for Turkey and Kharkof (fig. 2, *B*).

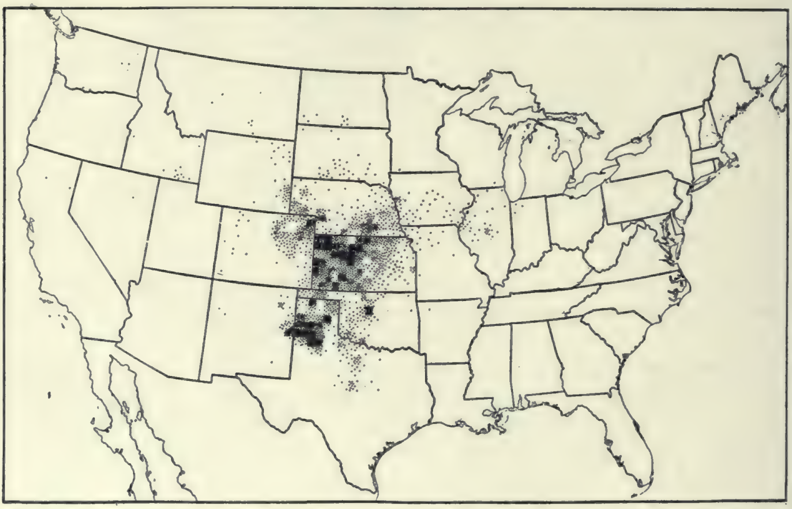


FIGURE 5.—Distribution of Kanred wheat in 1934. Estimated area, 2,928,980 acres.

Kanred originated from a head selected from a plot of Crimean wheat at the Kansas Agricultural Experiment Station in 1906. Crimean is identical with Turkey and had been imported from Russia in 1900 by the United States Department of Agriculture. After being thoroughly tested by the agronomists of the Kansas station, Kanred was distributed in 1917. The acreage increased very rapidly from 1917 to 1924, when it occupied more than 21 percent of the total hard red winter wheat acreage in the United States. Since that time the popularity of the variety has been gradually diminishing, owing to its weak straw and the distribution of better adapted varieties. In 1934, it was estimated that Kanred occupied nearly 3 million acres.

It was reported from 23 States; the largest acreage was in Kansas where it was grown on 1,351,000 acres, about 10 percent of the total acreage for the State (fig. 5).

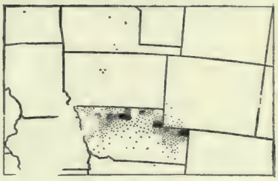
Kanred may be grown with success wherever Turkey is grown. In Kansas, Texas, Nebraska, Colorado, Oklahoma, and New Mexico it has partly replaced Turkey and Kharkof, and in all of these States except Nebraska it is a recommended variety. Outside of this area it has shown little advantage over Turkey.

In experiments Kanred has been found to be about equal to and much the same as Turkey in milling and bread-baking value. It has a slightly higher bushel weight and produces a greater percentage of straight flour than Turkey or Kharkof grown under the same conditions but has a slightly lower percentage of protein and produces a loaf of bread with a slightly smaller volume. In weight, texture, and color of loaf produced Kanred is about equal to Turkey or Kharkof. Kanred is now considered by the trade as equal to Turkey in quality.

NEBRASKA NO. 60

Nebraska No. 60 is a high-yielding selection of Turkey made at the Nebraska Agricultural Experiment Station in 1907 and distributed in 1918. It is later than Turkey, more winter hardy, and identical in appearance. It is as susceptible to rust and hessian fly attack as is Turkey. In milling and baking value it is equal to Turkey. This variety, rather than Turkey, is recommended where a little more winter hardiness is desired and where earliness is not so important.

Nebraska No. 60 is now grown in Nebraska, Colorado, Kansas, Oklahoma, and on a small acreage in South Dakota (fig. 6). Most of the acreage, however, is confined to Nebraska, where the variety is well adapted and popular, especially in the western part. It recommended by the respective State agricultural experiment stations for growing in Nebraska and Oklahoma. In some cases Nebraska No. 60 and Turkey have become mixed, and the identity of the former has been partly lost.



URE 6.—Distribution of Nebraska No. 60 wheat in 1934. Estimated area, 649,839 acres.

TENMARQ

Tenmarq was produced from a hybrid between Marquis spring wheat and P1066 winter wheat, the latter being a sister selection of Kanred made from Crimean wheat. The cross was made at Manhattan, Kans., in 1917. Tenmarq is the result of a selection made in 1921 by John H. Parker. The variety may be distinguished from Turkey by the longer beaks, slightly larger heads, stronger straw, earlier maturity, and shorter, plumper kernels.

Tenmarq is 3 to 5 days earlier than Kanred in maturity, but it is less winter hardy, being only slightly more hardy than Blackhull. It is resistant to some but not all forms of stem rust, has a stiffer straw, and lodges less easily than Turkey or Kanred. It is very susceptible to attack by the hessian fly. The milling and baking quality of Tenmarq is very good, being equal to or better than that of Kanred and Turkey.

Tenmarq was distributed in 1932, and in 1934 was reported as being grown in Kansas, Texas, and Oklahoma; most of the acreage was in south-central Kansas, as shown in figure 7. The total acreage in 1934 was reported to be more than 177,000 acres. It is estimated that more than 200,000 acres were grown in Kansas alone in 1936. From central Kansas south through Oklahoma and Texas, Tenmarq has given very good results in experiments, being one of the highest yielding varieties. Farther north it has given high yields only in years when there was no winter-killing and when early wheats were able to escape hot, dry winds. It appears that the variety may spread rather rapidly and replace much of the Blackhull acreage, owing to slightly better yields and a more desirable quality for baking. Tenmarq is a variety recommended by the agricultural experiment stations of Kansas, Oklahoma, Texas, and Illinois.

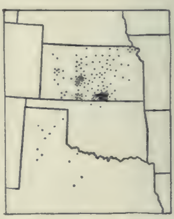


FIGURE 7.—Distribution of Tenmarq wheat in 1934. Estimated area, 177,746 acres.

MINTURKI

Minturki is the most winter hardy of any variety grown commercially, although others that are being grown for experimental purposes are able to survive severe winters. Minturki originated from a cross between Turkey and Odessa (the latter a beardless, soft red winter wheat) made at the Minnesota Agricultural Experiment Station in 1902. The variety was increased and was first distributed in 1919. It has gradually increased in acreage, mostly in southern Minnesota. Smaller acreages were reported from Illinois, Michigan, Ohio, Nebraska, Wisconsin, South Dakota, and Montana, as shown in figure 8.

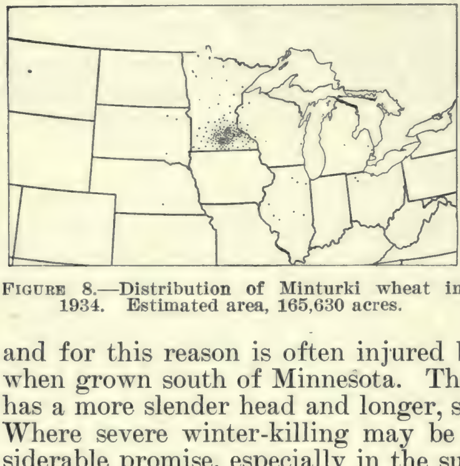


FIGURE 8.—Distribution of Minturki wheat in 1934. Estimated area, 165,630 acres.

Minturki has given very good yields in Minnesota and has done fairly well in experimental trials in central Utah and central Montana. It finds favor in that area also because of its resistance to the forms of stinking smut or bunt so far found in the Plains and its moderate resistance to stem rust. It ripens later than most varieties of hard red winter wheat and for this reason is often injured by heat and drought, especially when grown south of Minnesota. The variety resembles Turkey, but has a more slender head and longer, softer, and more slender kernels. Where severe winter-killing may be expected, Minturki offers considerable promise, especially in the sub-humid and humid sections of the upper Mississippi Valley. Bread from Minturki is satisfactory in volume and texture, but is inclined to be slightly yellow. The agricultural experiment stations of Minnesota, South Dakota, and Illinois recommend it for growing in those States.

IOBRED

Iobred was developed from a variety or a hybrid mixed with Banat and separated in 1915 by L. C. Burnett at the Iowa Agricultural Experiment Station. It is a brown-chaffed variety with much shorter and broader kernels than most varieties of the hard red winter class. In Iowa, it is considered superior to many other varieties with respect to winter hardiness, strength of straw, resistance to stem rust, and yields.

Iobred is grown in Iowa, Kansas, Illinois, Nebraska, Missouri, and Oklahoma. The greatest acreage is in Iowa, as is shown in figure 9. Because of its rust resistance and stiff straw, Iobred has become popular in a small area of southeastern Nebraska and northeastern Kansas on bottom land where other varieties lodge badly and become infected with rust. It may become more widely grown in Iowa because of its ability to withstand lodging. It is doubtful whether it should ever be extensively grown in drier regions because of its tendency to shatter. It is recommended for growing only in Iowa.

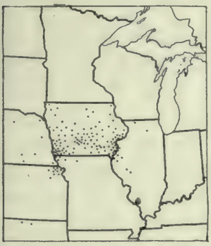


FIGURE 9. — Distribution of Iobred wheat in 1934. Estimated area, 112,874 acres.

KARMONT

Karmont is the result of a selection from Kharkof made in 1911 at the Judith Basin Branch Station, Moccasin, Mont. It was first grown commercially in Montana in 1921. The variety is very similar in appearance to Turkey and Kharkof, although it usually outyields these varieties under Montana conditions. In milling and baking it is equal to Turkey and Kharkof. Karmont is becoming generally grown in the Judith Basin of Montana, the area to which it is adapted and where it is recommended (fig. 10).

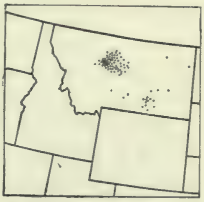


FIGURE 10.—Distribution of Karmont wheat in 1934. Estimated area, 90,448 acres.

REDHULL

Redhull, as commercially grown, is a mixture of types of hard red winter wheat. The predominating type is awned and has brown glumes with black stripes, whereas Blackhull has white glumes with black stripes. Redhull was selected from a field of Blackhull at Haven, Kans., by F. F. Tonn in 1921. It is now grown only in south-central Kansas and north-central Oklahoma and there only to a limited extent. In experimental trials it has produced lower yields than Blackhull. In quality it is about the same as Blackhull. It appears to have no superior qualities to justify growing it in preference to other varieties.

EARLY BLACKHULL

Early Blackhull differs from Blackhull principally in being about 8 days earlier and in having shorter straw. It is the earliest variety of hard red winter wheat now raised on farms. In comparative experiments it has been less winter hardy and also has yielded less on the average than Blackhull. Owing to the fact that it starts growth very early in the spring, late frosts may injure the variety, especially in southern States. In seasons of very mild winters followed by hot, dry summers Early Blackhull has given good yields, because of its ability to escape the damaging effect of heat and drought.

Early Blackhull was selected from a field of Blackhull in 1921 by A. P. Haeberle, Clearwater, Kans., who later increased and distributed it. It is grown on a limited area south and west of Wichita, Kans., where it is fairly popular because of its earliness. Rather disappointing results in 1935 caused many farmers to stop growing it. In quality it is probably poorer than Blackhull although generally, like Blackhull, it has a good test weight. It is probably too early and too easily winter-killed for use over a very wide area.

CHEYENNE

Cheyenne is the result of a plant selection made from Crimean (the same strain from which Kanred was selected) at the Nebraska Agricultural Experiment Station, Lincoln, Nebr., in 1922. It differs from Turkey in being more winter hardy, having shorter and stronger straw, denser and more erect heads, wider shoulders, and shorter beaks on the outer glumes. It does not shatter easily and is considered to be a good "combine" variety. It is tolerant of hessian-fly attack but is susceptible to bunt and stem rust. There is some evidence to indicate that Cheyenne is excellent for fall and winter pasture.

The protein content of Cheyenne usually is lower than that of Turkey, owing in part to its higher yield. Its baking characteristics appear to differ somewhat from those of Turkey. The Nebraska station has found that the dough requires more mixing than that of Turkey, but that, if mixed and fermented properly, Cheyenne will produce as good bread as that made from other varieties of hard red winter wheat.

In experiments dating back to 1927, Cheyenne has been a high yielder in plots at Lincoln and at other stations in Nebraska, Kansas, and Oklahoma. It was distributed in 1930 as Nebraska No. 50, but the seed became mixed, and a purified supply was distributed in 1933 as Cheyenne; since that time it has spread rapidly in Nebraska. It was estimated that in 1936 there were 100,000 acres of Cheyenne wheat in the State. It was reported in Kansas in 1934 as well as in Oklahoma, and the acreage is known to be increasing rapidly. The 1935 rust epidemic gave it a temporary set-back, but the variety has so many desirable characters that it is still popular. Cheyenne is recommended by the agricultural experiment stations of Nebraska, Oklahoma, and Illinois for growing in those States.

COOPERATORKA

Cooperatorka differs from Turkey principally in being taller and later, with a head inclined to nod, having purple stems, softer kernels, and in being less winter hardy. It is also resistant to certain forms of bunt. It was introduced from the Odessa Experiment Station, U. S. S. R., in 1928 by J. W. Pincus, then of the seed division of the Amtorg Trading Corporation, New York City. This seed was distributed to experiment stations and seed growers in the United States. The variety was also introduced from U. S. S. R. in 1927; it was increased and sold as Kooperatka in Kansas. It is also known in Kansas as Russian and Improved Turkey. The variety is grown on a limited acreage in Kansas, but has never become popular because of its lack of winter hardiness.

UTAH KANRED

Utah Kanred differs from Kanred in having longer, laxer, and more nodding spikes, darker glumes, and more variable and shorter beaks, and in being less winter hardy. In experiments in the Nephi Dry-Land Substation, at Nephi, Utah, this wheat proved to be a high-yielding variety and was distributed in 1922. The original source is unknown. When distributed, it was thought to be Kanred and, having been grown commercially as Kanred for many years is now designated as Utah Kanred. It is grown in Utah only.

EAGLE CHIEF

Eagle Chief is a mixture or a segregating population from a field cross of Turkey and Fulcaster or some other soft wheat. The original bulk section was made by C. H. Hyde, at Alva, Okla., in 1920 from a field of Kharkof. The seed was increased until 1927 when about 2,000 bushels were sold by the originator. The variety, which is a mixture of types, is grown in Oklahoma and on a limited acreage in Texas. It has little to recommend it.

MONTANA NO. 36

Montana No. 36 is identical with Turkey and Kharkof in all observable characters. It is a selection from Kharkof, made at the Montana Agricultural Experiment Station, from which it was distributed in 1915. The wheat has been grown for a number of years in Montana, the acreage remaining fairly constant over a 10-year period. It is as winter hardy as Turkey or Kharkof and has given slightly higher yields in some sections of Montana. It also is equal to these varieties in milling and baking quality. The variety is on the recommended list for Montana.

IOTURK

Ioturk is similar to Turkey, differing from it in consistently higher yields in Iowa. It is also resistant to some forms of bunt. Ioturk is a Turkey selection made by the farm crops section of the Iowa Agricultural Experiment Station, Ames, Iowa. It was distributed in 1926 but has never become very popular, being grown on only about 9,000 acres in 1934; nearly all of this was in Iowa, with very small acreages in Illinois and Missouri. In Iowa and Illinois, Ioturk is an approved variety.

IOWIN

Iowin is a selection from Theiss wheat made by L. C. Burnett at the Iowa Agricultural Experiment Station. It was first grown commercially in 1930. It differs from Turkey in being taller and later, in having longer beaks, purple stems, and slightly softer kernels. It is also resistant to stem rust. Under Iowa conditions it has given higher yields than Turkey. Nearly all of the acreage of Iowin is in Iowa, where it is an approved variety, and it occupied slightly more than 8,500 acres in 1934. In the same year it was reported as being grown on a few acres in Kentucky.

ILRED

Ilred is a pure-line selection from Turkey made at the Illinois Agricultural Experiment Station, Urbana, Ill., in 1910. It was first grown commercially in 1923 as Turkey 10–110. It has not become an important variety, and all of the acreage is confined to Illinois, where it is a recommended variety, as it seems to have the ability to outyield Turkey.

SHERMAN

Sherman differs from Turkey in that it has stronger straw, shatters more easily, and has longer beaks and softer kernels. It is resistant to some forms of bunt. Sherman was first distributed from the Sherman County Branch Station, Moro, Oreg. It is the result of a selection made in 1915 by J. A. Clark at Moccasin, Mont., from a double cross between Budapest × Turkey and Zimmerman × Turkey made by M. A. Carleton in 1908. It was distributed in southern Idaho by the Idaho Agricultural Experiment Station in 1928. The variety is now grown on small acreages in Utah and Idaho, although it has not been formally recommended by the agricultural experiment station in either State.

OTHER BEARDED VARIETIES

In addition to the varieties discussed above, other bearded varieties are grown on limited acreages in various parts of the United States. Some of these are new, just coming into production and others are old ones slowly being dropped. In no case is any one variety being grown on as many as 5,000 acres.

Oro, a selection from Turkey developed by D. E. Stephens, of the station at Moro, is resistant to many forms of bunt and is grown sparingly in Oregon and Idaho. Although it is a recommended variety in Oregon, it has not yet become widely grown, but it has been very extensively and successfully used as a parent in hybrids. It has many desirable characteristics, but has not been able to equal other good varieties in yield.

Yogo is another smut-resistant variety first distributed from the Judith Basin Branch Station, Moccasin, Mont., in 1932. It also is a high-yielding, winter-hardy variety. It is the result of a Minturki × Beloglina-Buffum cross made in 1919 at Manhattan, Kans., by J. H. Martin and K. S. Quisenberry, of the United States Department of Agriculture. The selecting and testing work at Moccasin was done largely by K. S. Quisenberry, B. B. Bayles, and J. L. Sutherland. Yogo is now recommended by the Montana Agricultural Experiment Station and is becoming a commercially grown variety.

Ashkof was developed at the Ashland branch station of the Wisconsin Agricultural Experiment Station. It is a selection from Malakof and has brown glumes. It is fairly winter hardy, gives a good yield under Wisconsin conditions, and is resistant to some forms of bunt. Ashkof is a recommended variety in Wisconsin, and a small acreage was reported in Tennessee in 1934.

Wisconsin Pedigree No. 2 is a selection from Turkey developed by the Wisconsin Agricultural Experiment Station and distributed as a high-yielding strain in 1918. The variety is now recommended and grown only in Wisconsin and Illinois.

Nebraska No. 6 is nearly identical with Nebraska No. 60 and has the same history as that selection. In both yield and quality it is slightly inferior to Nebraska No. 60. It is now grown on a very small and decreasing acreage in Nebraska but is no longer recommended for that State.

Ukrainka is a Turkey-type introduction from Russia. It is similar to Turkey except that the kernel is somewhat softer. This variety has been distributed by the Illinois Agricultural Experiment Station and is grown only in Illinois.

Rio is a selection made by D. E. Stephens at Moro, Oreg., from Argentina, a Crimean wheat. The variety is resistant to many forms of bunt and for that reason was distributed in 1931 and still is a recommended variety for growing in Oregon.

Relief differs from Turkey in being taller, having a longer and laxer spike, darker glumes, shorter beaks, and a slightly longer kernel, and in being resistant to some forms of bunt. The variety was selected from a cross between Hussar and a Turkey selection (Utah No. 26) by D. C. Tingey, of the Utah Agricultural Experiment Station, Logan, Utah. It has shown resistance to the forms of bunt that cause heavy losses in the Cache Valley of Utah. Relief was distributed in 1934 and is now recommended for growing in Utah.

Four other bearded varieties, Beloglina, Bacska, Iowa No. 404, and Regal, are grown on very small acreages in isolated places in the United States, but are not recommended in any State.

GROUP 2.—HEADS BEARDLESS

Only five beardless varieties of hard red winter wheat are grown on a commercial scale. These are described in the following paragraphs.

RIDIT

Ridit was developed at the Washington Agricultural Experiment Station from a cross between Turkey and Florence, made by E. F.

Gaines in an effort to produce a variety of winter wheat resistant to bunt or stinking smut. The cross was made in 1915, and a selection made from it in 1919 resulted in Ridit. Its outstanding characteristics are resistance to many but not all forms of bunt and resistance to shattering; it produces high yields and has good milling qualities. Ridit was first distributed for commercial growing in Washington in 1923, and since that time it has rapidly increased in acreage (fig. 11).

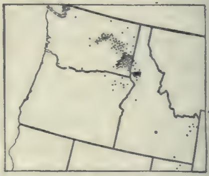


FIGURE 11.—Distribution of Ridit wheat in 1934. Estimated area, 159,402 acres.

According to the 1934 survey, Ridit was grown on nearly 160,000 acres, mostly in Washington, Idaho, and Oregon. Ridit is grown more extensively than any other beardless variety of hard red winter wheat. It is recommended in Washington and is best adapted to eastern Washington and the adjacent Panhandle of Idaho, where winters are rather mild. It is not able to withstand severe winter conditions.

MICHIKOF

Michikof was developed at the Indiana Agricultural Experiment Station from a cross made in 1912 between Michigan Amber and Malakof. The selection from which the variety originated was made in 1915, and the variety has been grown commercially since 1920. The acreage is confined to Indiana and Illinois, the total in 1934 being slightly more than 90,000 acres. It is not now a recommended variety in either State. Its outstanding characteristics are winter hardiness and hard kernels of high-test weight which make flour of good quality for bread making. There has been some opposition to Michikof from millers of Indiana, since they prefer soft wheats for local milling.

NEWTURK

Newturk is a selection from a cross between Newton and Turkey, made at Moro, Oreg., in 1916. In the fall of 1920 many beardless selections of this cross, made by J. A. Clark, were sent to and seeded at Moccasin, Mont. One of these, later named Newturk, which proved to be the best, was distributed in 1925 for commercial growing in Montana. Its acreage has increased steadily, but the variety is not grown in any other State.

Newturk was developed to satisfy a demand for a beardless variety of hard red winter wheat which would yield as well as Turkey or Kharkof. It yields as well as or slightly better than Kharkof in Montana, is resistant to shattering, and has good quality for milling and bread making. While it has been tested in States other than Montana and has given fairly good results, it probably is best adapted to Montana, where it is a recommended variety. In Montana it may safely be used to replace Kharkof by those farmers who desire to grow a beardless variety rather than a bearded one.

MOSIDA

Mosida is a variety having strong straw; it is fairly winter hardy and gives high yields on the cut-over lands of northern Idaho. It should not be grown where shattering is likely to occur.

Mosida originated from a cross between Fultzo-Mediterranean and Turkey made in 1916 at the Colorado Agricultural College. The crossed material was taken to the Idaho Agricultural Experiment Station, Moscow, Idaho, where the selection that is now called Mosida was made in 1918. It was released for commercial growing in northern Idaho in 1924. In 1934 it was reported as grown in Idaho, Oregon, Washington, and Montana, the largest acreage being in Idaho.

ALTON

Alton (Ghirka Winter) differs from Turkey in having beardless heads and shorter and softer kernels with a very small germ. It is of medium height and is midearly in ripening, being usually a day or two later than Turkey. The straw is stiffer than that of Turkey, and the heads are slender and tapering.

Alton was introduced into the United States from Russia by the United States Department of Agriculture in 1900. It has been grown to a limited extent in Colorado, Wyoming, and Kansas under other names, principally Ghirka Winter, but is not grown extensively in any State. The popularity of the variety has decreased until in 1934 only a small acreage in Oklahoma was reported. It has been unable to compete with the better bearded varieties. In milling and baking Alton is not the equal of most other hard winter wheats, and it should be eliminated.

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LAMB AND MUTTON ON THE FARM

FARMERS' BULLETIN
No. 1807
U.S. DEPARTMENT
OF AGRICULTURE

THE EASE with which lambs and sheep can be slaughtered on the farm makes them a convenient source of fresh meat for family use.

Handy-weight 25- to 45-pound lamb carcasses yield comparatively small cuts, all of which are normally tender. Any surplus that cannot be used fresh, or shared with a neighbor, may be canned or frozen. Some cuts can be cured satisfactorily. This meat can be kept as an emergency food reserve or as a source of variety in the diet.

Because of the general preference, in the United States, for lamb rather than mutton, the greater part of this species is slaughtered at the lamb stage. The directions and discussion in this bulletin for the preparation of lamb apply to mutton also unless otherwise specified. Some persons prefer the flavor of mutton to that of the less-mature lamb.

This is a revision of and supersedes Farmers' Bulletin 1172, Farm Slaughtering and Use of Lamb and Mutton.

Washington, D. C. **Issued August 1938**

LAMB AND MUTTON ON THE FARM

By K. F. Warner, *senior extension meat specialist, Animal Husbandry Division, Bureau of Animal Industry*

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CONVENIENCE OF LAMB FOR HOME USE

THE PERIODIC DRESSING of home-raised lambs affords a means of adding a desirable variety of fresh meat to the family diet. Lambs are quickly dressed, and the handy-weight cuts are normally tender. The entire carcass is small enough so that with household refrigeration one or more families can ordinarily consume the meat before the problem of spoilage appears even in the summer.

An 80-pound lamb produces a dressed carcass weighing about 36 to 40 pounds. The yield may vary above or below that range because of several factors, including degree of finish and weight of pelt, but 47 to 50 percent of live weight is a good average dressing percentage. The trimmed leg roasts from a 40-pound carcass will weigh about 6 pounds each, and the shoulder roasts about 5 pounds apiece. There will be about 7 pounds of breast and neck and 8 pounds of loin and rib to be roasted or cut into about 30 medium-thick chops.

All these cuts are normally tender enough to be adapted to cooking in any of several ways. The shoulder and even the breast may be oven-roasted if that procedure is preferred to braising the breast with vegetables. Cold roast lamb is an excellent filler for sandwiches, and the leftovers from any lamb dish can be made into a wide variety of tasty combinations.[1]

FLAVOR OF LAMB

About two-thirds of the lamb eaten in the United States is consumed in the section that lies north of Washington and east of Pittsburgh. Only a very small amount of lamb is eaten by the residents of rural areas. It seems probable that this sectional popularity of lamb is caused not so much by inherent differences in the tastes of the respective populations as by established and accepted food habits. Many farm families, who formerly were not familiar with lamb, have found that they enjoy its characteristic flavor and have added this convenient fresh meat to their regular diet.

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[1] For information regarding the methods of cooking lamb, see Leaflet 28, Lamb as You Like It, issued by the U. S. Department of Agriculture.

Contrary to the opinion of some consumers that the fell or thin, paperlike membrane covering the lamb carcass is the cause of the characteristic flavor, this covering does not affect the flavor and has been found to serve the useful purpose of preventing the meat from drying out during storage and when being roasted. Even slow skinning of a lamb, which was thought to have some effect on the flavor of the meat, has been found to have no influence, provided the carcass is kept clean during the process of dressing. Care should be taken to keep the carcass clean while it is being dressed, but if the dirt or grease of the wool soils the meat accidentally, prompt and thorough washing with a clean cloth and hot water will prevent serious damage.

FACTORS AFFECTING QUALITY

The desirability of lamb as a meat for home use or for market depends on four principal factors, as does that of other meat. These factors are the breeding of the animal, how and to what extent it has been fed, the age at which it is slaughtered, and the method of handling the meat.

Lambs of the so-called mutton breeds are generally more suitable for meat than those of breeds bred primarily for wool production. The advantage of using lambs of the mutton breeds for meat is that they usually fatten more readily, dress a higher proportion of carcass to live weight, and yield meatier roasts and chops.

A well-finished lamb yields a carcass that is fairly well covered with fat over the legs and shoulders as well as over the back. However, a high degree of finish is not essential for a lamb that is to be slaughtered for home use. A lamb that is moderately well fattened and has been making fairly rapid gains should produce a carcass having tender, desirable meat.

The term "mutton," as commonly used commercially, applies to the meat of older sheep, that is, ewes (over 12 months of age) and wethers (over 18 months of age). Such meat, especially that from well-fed sheep, though frequently less tender than the meat from the younger lambs, also is suitable for family use.

Only a very small proportion of sheep and lambs examined by the Federal meat-inspection service are found badly diseased. Nevertheless care should be taken to see that all animals selected for slaughter are thrifty and healthy.

SLAUGHTERING EQUIPMENT

A sharp knife, preferably a skinning knife, a steel, and a saw are the principal tools needed to dress a lamb. The equipment should include about 6 feet of clean quarter-inch rope with which to hang the lamb to a stoutly anchored 2- by 4-inch beam or a tree limb about 7 feet from the ground. A bench, box, or even a clean floor upon which to lay the lamb, a tub for the offal, a pan or bucket for heart, liver, and tongue, a bucket of hot water, and a few clean cloths complete the list.

SLAUGHTERING AND DRESSING LAMBS

Lambs or sheep selected for slaughter should be penned the day before so that they can be caught without running or exciting them. Water should be supplied freely, but all feed should be withheld for 24 hours before slaughtering. This will make dressing easier.

STICKING

A lamb should be held for sticking so that the blood will not drain into the fleece, making it difficult to do a clean job of skinning. A lamb may be laid down on a box or bench (fig. 1), but an easier, cleaner job of sticking can usually be done by tying the hind legs together and suspending the lamb from a beam, limb, or other stout support that is about 7 feet from the ground (fig. 2). Hold the lamb's nose in the left hand, being careful not to shut off its breath. Run a sharp, pointed knife clear through the neck close to the neck bone just behind the angle of the jaw and below the base of the ear. Cut out at right angles to the neck. If the knife was not close enough to the neck bone to pick up and sever the main arteries and veins, cut back to or against the bone.

STUNNING

The stuck animal should be promptly stunned by breaking the neck. To do this, grasp the nose with the left hand and the wool on the poll (between the lamb's eyes) with the right. Pull the nose up and back and push down hard on the poll with the heel of the right hand (fig. 3). If the muscles next the neck bone have been cut in sticking, the big atlas joint at the base of the head should break open rather easily. Stunning the animal is a humane procedure.

SKINNING THE LEGS

The well-bled lamb is laid on a clean floor or platform for skinning. There are many ways to remove the pelt. The one described here is not the quickest but is ordinarily the easiest for the beginner to learn. The pelt is opened by removing a narrow strip of skin from the front of the front legs and from the back of the hind legs. The pelt is then pushed or "fisted" off the brisket, belly, and flanks before the carcass is hung up again.

Stand at the side of the lamb, holding the front leg between the knees with the carcass leaning away, thus stretching the leg tight (fig. 4). Raise a narrow strip of pelt from below the lamb's knee to the hoof head. Extend the opening in the pelt from the point below the knee to a point well in front of the brisket. Care should to be taken not to cut too deep or through the paper-thin, protective membrane, or fell, that envelops the meat just underneath the skin. To avoid cutting through the fell and into the meat, the beginner should "choke" the knife, hold it with the cutting edge up against the skin, rather than toward the meat, and cut with a short, curving, wrist motion that swings only the point of the knife against the pelt (fig. 5). The left hand raises the pelt from the meat and holds it tight while the knife is turned against it.

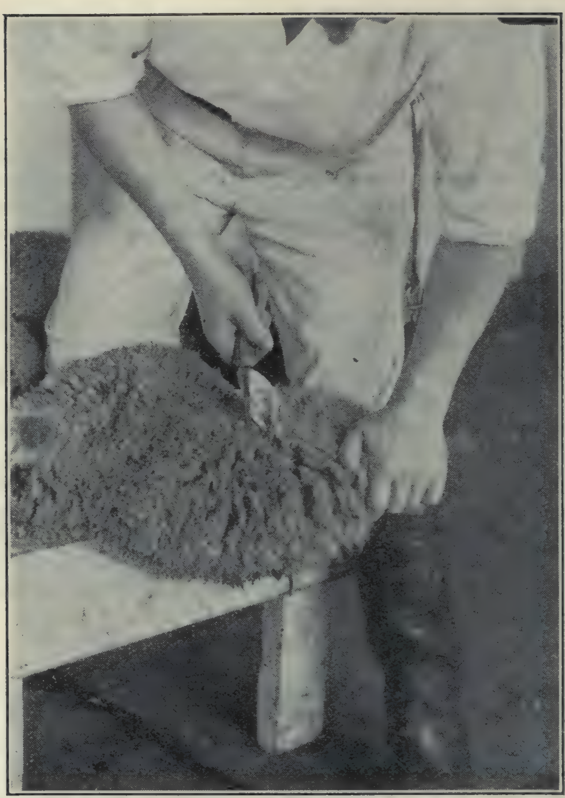

FIGURE 1.—Sticking a lamb on a bench. Pressure from the operator's right knee holds the lamb in place.

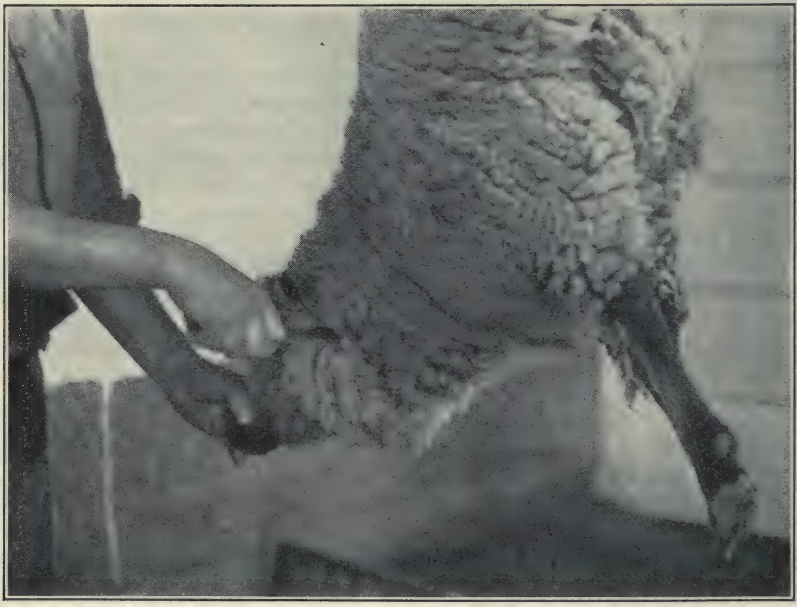

FIGURE 2.—Sticking a lamb when suspended. With the left hand hold the head securely, to prevent its swinging.

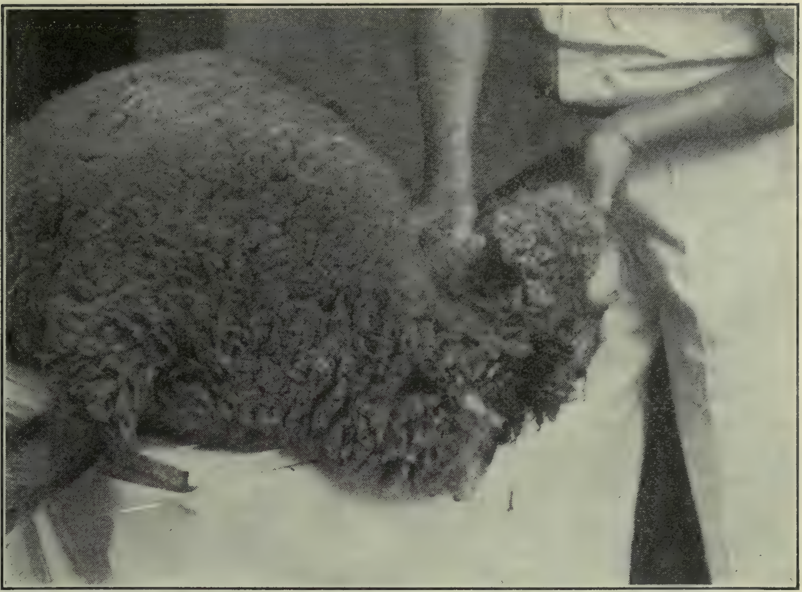

FIGURE 3.—Stunning a lamb. Pull the head up and back with the left hand and push down hard with the heel of the right hand.

The opening over the front of the left leg joins that made over the right leg in front of the brisket. The pelt is then opened down the neck to the opening made by sticking.

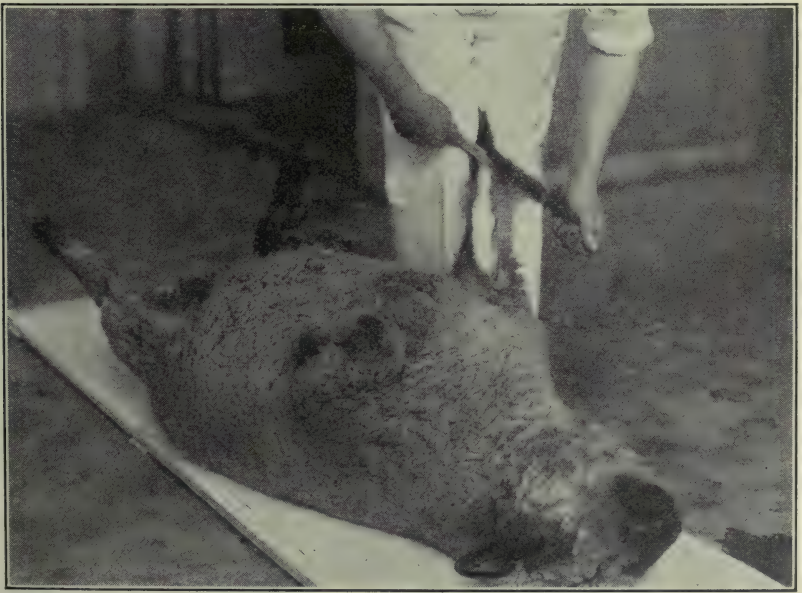

FIGURE 4.—Opening the pelt over the front of the front leg. Keep the edge of the knife against the leg rather than up against the skin.

The V-shaped strip of pelt over the brisket that has been formed by opening the fleece over the front legs is grasped at the point or head end and pulled up and back over the brisket (fig. 6). If the pelt sticks to the brisket and the fat and fell begin to tear, pulling should be stopped and fisting begun.

The hind leg is held between the knees, in the same manner as the front leg, and a strip of pelt raised from a point below the hock along the tendon and into the hoof head. The cut is extended to a point just in front of the anus, using the same careful, rotary wrist motion to prevent the point of the knife cutting into the choice leg muscles. Still holding the leg between the knees, skin out the hock and leg and then unjoint the foot at the lowest joint or the one next the hoof (fig. 7). If the foot has not been properly unjointed at the hoof head, as described, these tendons may pull out when the carcass is hung.

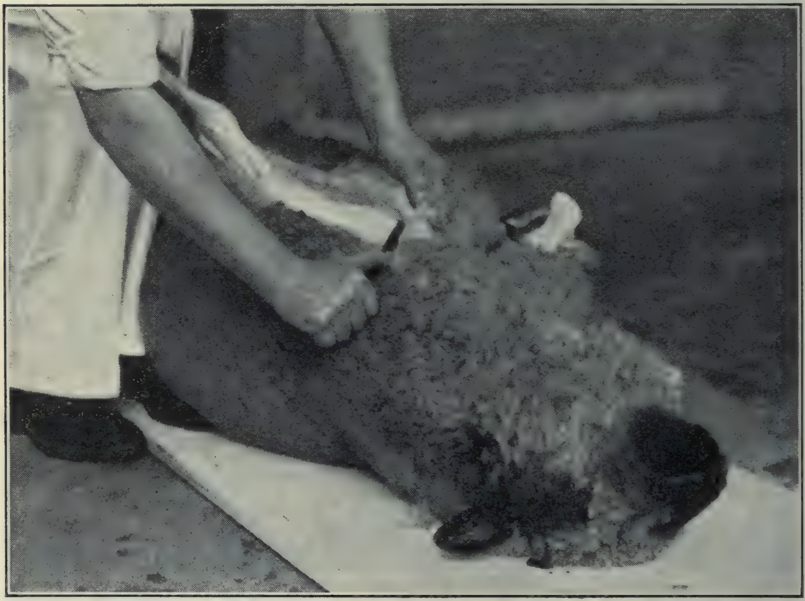

FIGURE 5.—Opening the pelt in front of the brisket. Slow, short strokes up against the pelt will prevent cutting down into the meat.

Slip the knife between the leg bone and the tendons to make an opening for the string or gambrel used in hanging the carcass. Note that there are two tendons. Be sure to raise both as one may not be strong enough. Skin out the other hind leg and, grasping the pointed strip of pelt, pull it back over the cod or udder as far as it will go without tearing the flesh (fig. 8).

FISTING THE PELT OFF THE BELLY

Lay the lamb, back down, on a bench or box of convenient height. Clean hands are necessary to produce a clean carcass. The bucket of hot water and dry cloths should be available to wash and dry the hands whenever they become soiled.

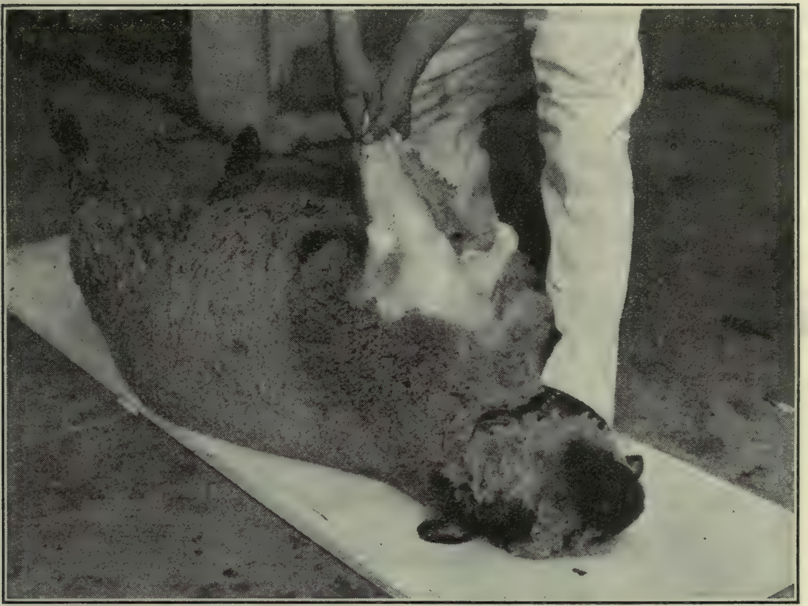

FIGURE 6.—Pulling the pelt over the brisket. Hold the pelt at the end and pull steadily.

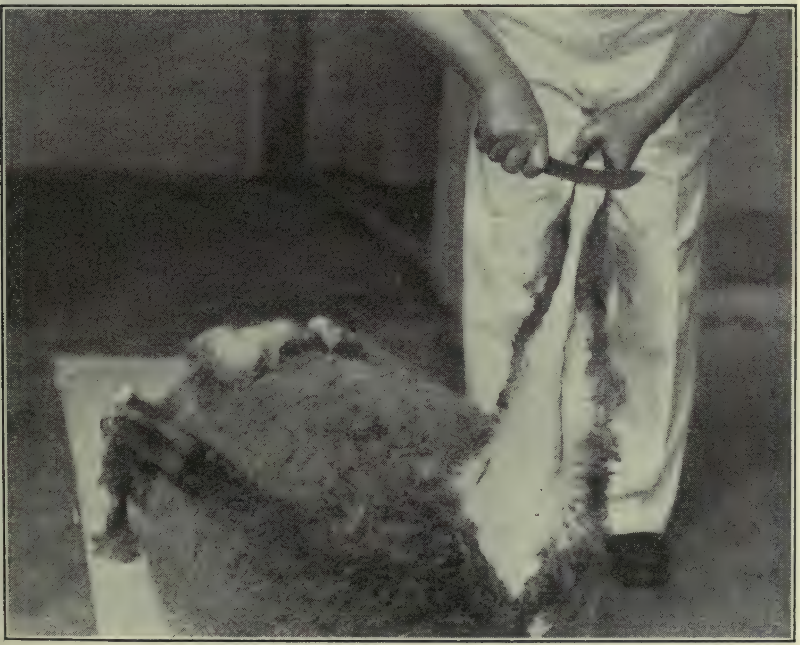

FIGURE 7.—Unjointing the foot from the skinnned hind leg.

The clenched fist is used to wedge in between the pelt and the fell. The thumb lies on top of the first finger and is used to lead the fist in under the pelt. The motion and pressure of the fist are up against the skin, pushing and working it away from the meat, rather than pushing the meat away from the skin. The left hand follows along just above the right, grasping the wool and holding the skin taut as the fist pushes against it underneath. Jamming through the fell and muscles of the carcass with the fist will result in an unattractive carcass but will not ruin it. With a little experience one can soon tell by the feel whether fisting is proceeding properly.

Fist in on one side of the brisket, loosening the pelt to the navel or as far down as can be reached conveniently (fig. 9). Work down behind the shoulder but do not try to loosen the pelt along the whole side. Fist in on the other side of the brisket and repeat the operation. The pelt usually sticks to the brisket. Sometimes it can be worked off from behind. Often the thumb can work it loose from each side. Occasionally a knife is needed to cut the skin from the center of the brisket. Young and well-fattened lambs skin more easily than older and thinner sheep.

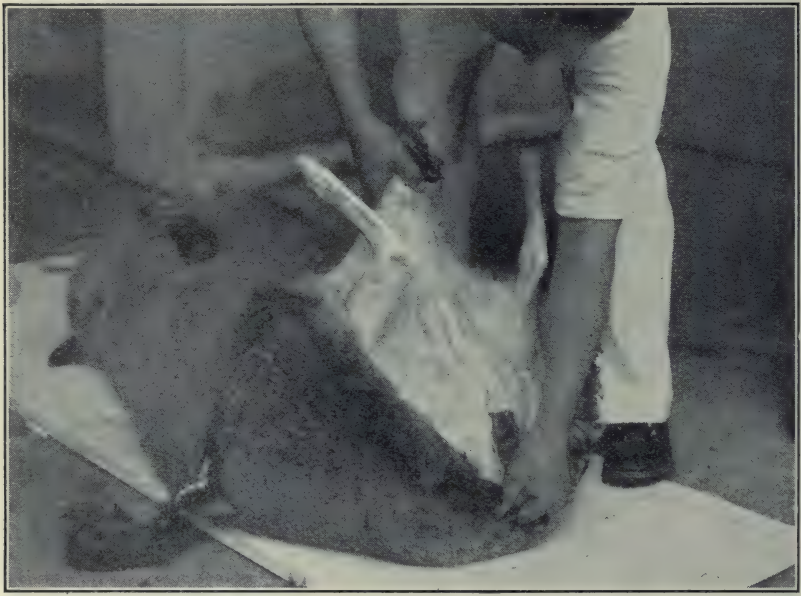

FIGURE 8.—Pulling the pelt free up to the cod or udder.

To loosen the pelt at the rear, stand between the hind legs, grasp the pelt with the left hand, and work the right fist down the center or over the cod or udder to the navel. The hand and arm are then pushed sideways, freeing the pelt over the flank and inside of the hind leg. Note that fisting is begun down the middle instead of at the side as was done when skinning the brisket. This lessens the danger of getting beneath and tearing the flank muscles that show plainly in figure 12.

REMOVING THE PELT

When the legs are skinned and the pelt fisted off the belly, heavy clean cord is run beneath the tendons of the hind legs, and tied around the legs, or a gambrel may be inserted, and the carcass suspended. A hook or support about 7 feet from the floor gives a good working height.

Cut the pelt open down the middle of the belly, cutting loose the navel (fig. 11). Holding the pelt tight with the left hand, work the right fist around the stifle and then up the outside of the left leg (fig. 12). Change hands, or cross hands, and fist out the lamb's right hind leg. This rolls the fleece away from the clean carcass.

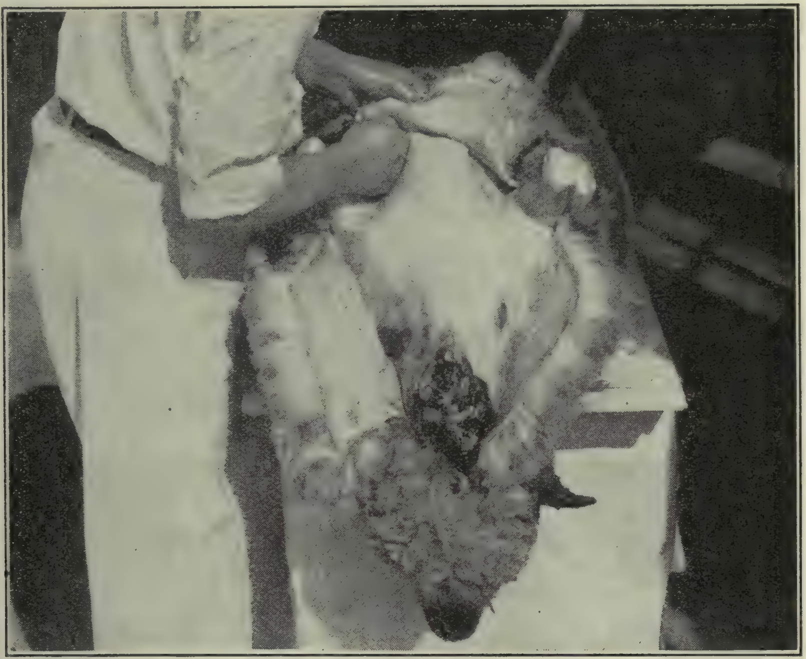

FIGURE 9.—Fisting the pelt down the side of the brisket. Note the white, clean, unbroken fat and fell.

Fist down past the shoulder, pull the skin free from the foreleg, and fist out the side of the neck (fig. 13). Push the pelt free from the sides and fist off the rump. The rump may stick, and it will be necessary to free it by working from both sides. From underneath the dock push up until the pelt hangs only by the skin that is fastened to the anus and tail (fig. 14).

There is a true joint at the lower end of the sheep's front leg bone which must be opened to cut off the pastern and foot of mature sheep. Just above (up the leg from) the true joint is a cartilaginous suture in the bone that can be broken apart on most lambs. This suture or "lamb joint" (fig. 15) is at the widest bulge in the end of the foreleg, or just above the true or "mutton joint." It is customary to cut off the forefeet of lambs at this suture, thus identifying the carcasses as those of lambs. Cut or nick the membranes on the side of the leg just

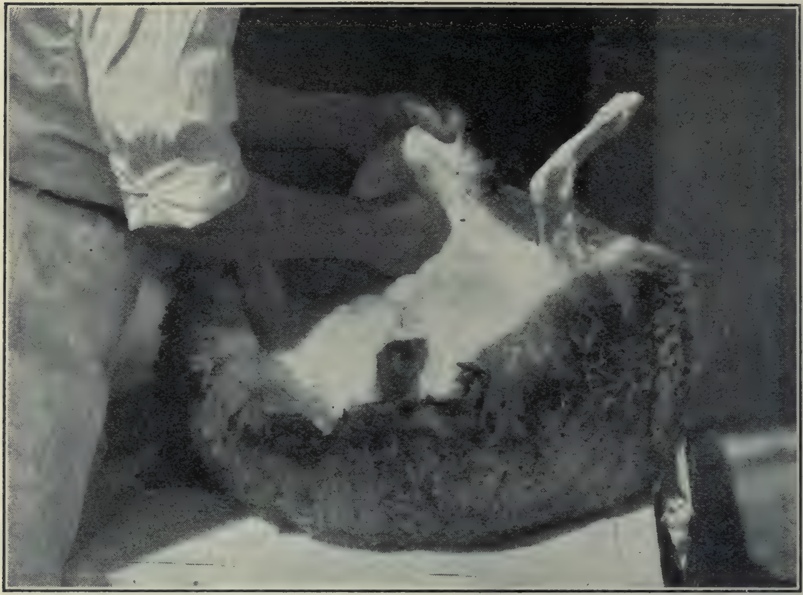

FIGURE 10.—Holding the pelt tight and pushing the fist forward over the cod or udder.

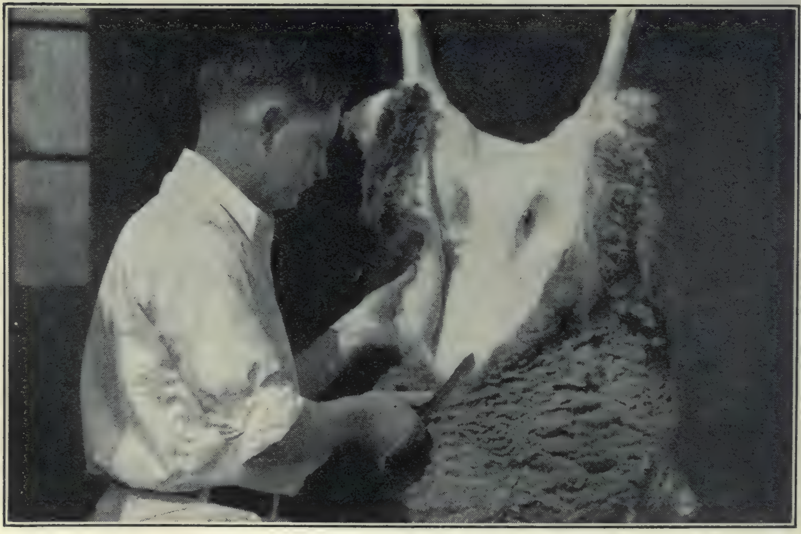

FIGURE 11.—Opening the pelt down the middle.

over this lamb joint. Break the joint open where it has been cut by pressing the foot sideways. The operator may hold the leg against his knee if necessary.

While the pelt is still hanging to and stretching the tail, push the knife in beside and above the anus, cut clear around it and loosen the anus so that 10 or 12 inches of the colon can be pulled up and out of the body cavity. The colon should be emptied or tied before it is dropped back into the body cavity so that its contents will not foul the carcass. Cut and pull the skin free from the dock and pull and fist it free from the back. If the fell or muscles start to tear, it is often possible to start fisting below the break, working up and around it, thus avoiding further tearing.

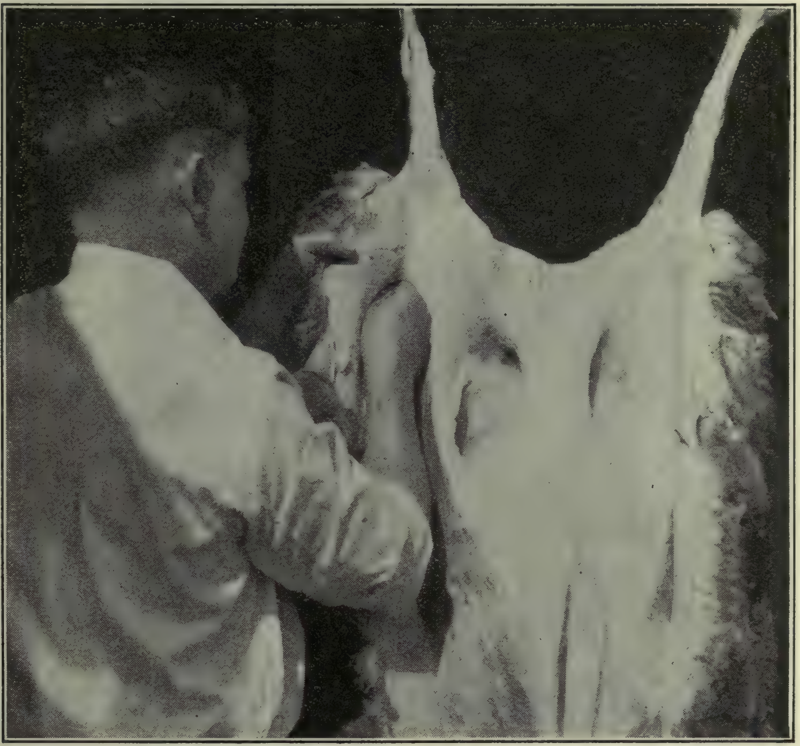
FIGURE 12.—The fist wedges in and up along the leg.

Pull the pelt down the neck (fig. 16) to the ears and cut off the head through the atlas joint. Wash the carcass with water as hot as the hand can stand, in order to clean and bleach it. Wipe dry with clean cloths wrung out in hot water.

DRESSING THE CARCASS

Open the carcass down the middle from just below the cod or udder to the cartilage of the breastbone or brisket (fig. 17). Be careful not to cut into the paunch. Allow the paunch and intestines to roll out and hang. Unless the lamb is full of feed the paunch should not break loose. Reach in and find the already loosened colon and pull and work it down past the kidneys. Grasp and remove the bladder, taking care not to spill its contents on the meat. The rest of the operation is similar to that of dressing hogs. Roll out the paunch slightly and get a firm grip on it with the left hand where it joins the intestines. Work the right hand into the body cavity, up the ribs and behind the liver, tearing the liver free where it is attached near the right kidney. Still keeping a firm hold on the viscera, work the right hand under the paunch along the diaphragm and pull and push the organs up and from the carcass. Tie the gullet with a stout cord where it enters the chest cavity; then cut the paunch free by severing the gullet below the cord. Tying prevents the escape of digestive contents when the gullet is severed. A helper will be needed in making the tie and cutting the gullet. Lay the offal in a clean tub for later inspection.

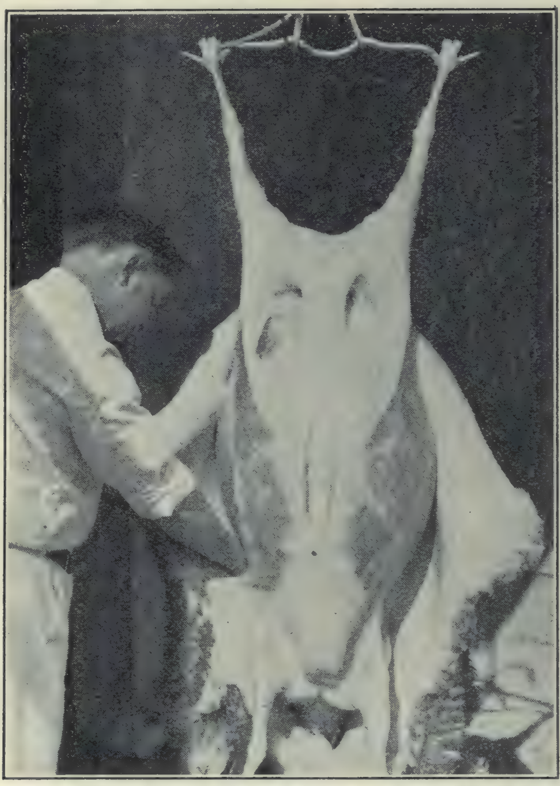

FIGURE 13.—Pushing the pelt away from the foreflank and shoulder.

Split the breastbone or brisket. If the animal is over 1 year old, a saw may be needed as well as a knife. To remove the pluck (heart and lungs), cut the white part of the diaphragm, cut free the pluck on each side of the brisket, loosen the large blood vessels along the backbone, and pull the pluck down and out (fig. 18). Wash the carcass and wipe it dry.

CARE OF THE INTERNAL ORGANS

Use care in removing the liver, as it is a choice product. Remove the gall bladder from the liver by pinching under the neck or small end of the bladder with the thumb and forefinger. Tear or cut the upper or smaller end free and pull gently to peel out the main body of the bladder. Another method is to cut it out with a knife. If the gall bladder breaks and the gall spills on the liver or carcass, wash promptly to remove any possible bitter flavor.

The liver, heart, and tongue should be carefully washed in cold water and hung up to chill. The head may be split open and the brains removed. The caul fat, if clean, may be used in cooking. The small intestines are separated easily from the fat by pulling carefully with the hands. It is always advisable to strip the contents from the intestines and open the fourth or true stomach to see if tapeworms or stomach worms are present. The lungs and liver should be examined also for the presence of other parasites or disease that may be making headway in the flock.

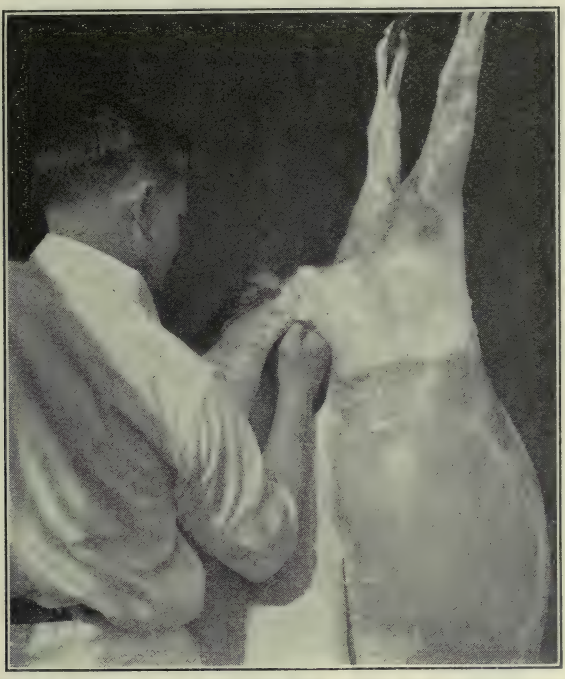

FIGURE 14.—Fisting the pelt free from the back. The next step will be to cut the pelt free from the dock.

The freshly slaughtered carcass and edible organs should be chilled to a temperature above freezing and below 40° F. as soon as possible. Fresh meat, in commercial establishments, is held at about 34° for storing and ripening.

CHILLING LAMB CARCASSES

The changes that occur in the carcass of a lamb must be controlled by proper temperatures if a desirable quality of meat is to be available to the family over a reasonable period. The functions of proper temperature in storage are (1) to prevent or delay the growth or action of molds, bacteria, yeasts, and other agents that develop taint, or spoilage, and (2) to permit the normal action of enzymes or other ripening agents present in meats that increase the tenderness of the meat during the first week or 10 days after slaughter.

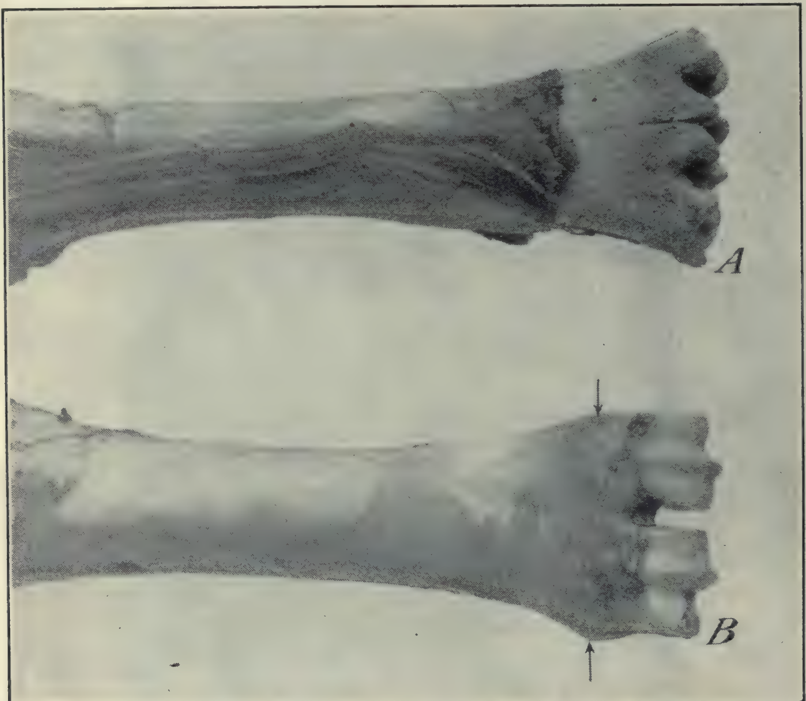

FIGURE 15.—The two types of joints of the foreleg: *A*, the false or "lamb joint," and *B*, the true "mutton joint" of a mature sheep. Arrow indicates the location of the lamb joint or suture.

The freshly dressed carcass should be protected from dust and sunlight and hung where it will chill promptly. If natural temperatures are above 40° F., artificial refrigeration is desirable. In properly designed dry coolers, well-fattened lamb is often held for 2 weeks or longer. At temperatures above 40° mold and other surface contamination develop more rapidly and the storage period would have to be relatively shorter.

If natural temperatures are low, an effort should be made to protect the meat from freezing so that the ripening process will not be delayed or stopped. After about a week the ripened cuts are often put in a room, pantry, or other storage place where subfreezing temperatures prevail.

A clean carcass, protected by dry, unbroken fell or fat, will keep for a longer time than thin meat or meat that has been contaminated in dressing or gashed so that the moist lean meat is exposed.

It is often necessary to use portions of a lamb within 4 or 5 days after the animal has been dressed. The braising or stewing cuts should be chosen for this early use if possible, thus allowing the chops and roasts time to ripen properly.

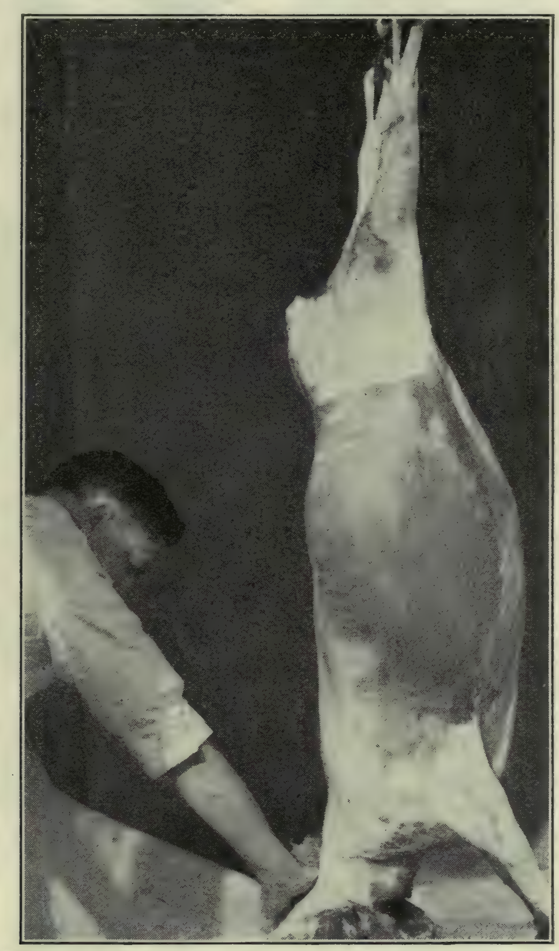

FIGURE 16.—Pulling the pelt free from the neck. This step should be easily accomplished if the sides have first been fisted free.

CUTTING THE CARCASS

Cutting methods vary with custom or locality, but all methods follow the main principle of separating the thin parts, which are more suitable for braising, from the thicker portions, which are adapted to roasting and broiling. With that principle as a guide, remove the thin portions, such as the breast, flank, plate, brisket, and foreleg, on a line beginning at the front part of the hind leg

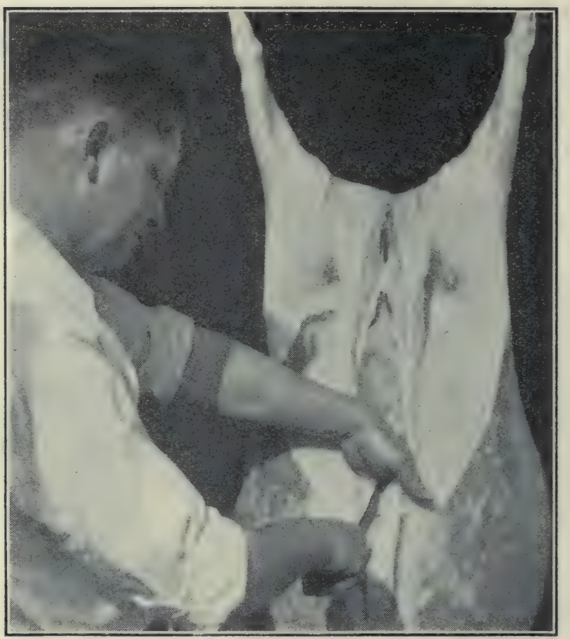

FIGURE 17.—The fingers of the left hand holding the internal organs away from the knife while opening the carcass down the front.

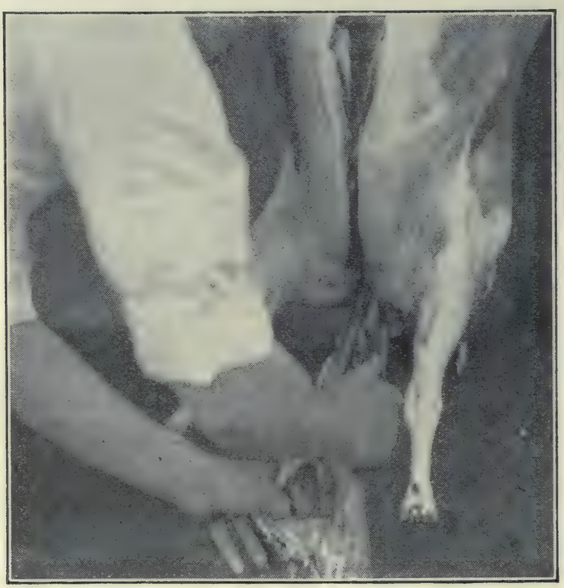

FIGURE 18.—Removing the heart and lungs after splitting the brisket.

and running to a point just above the first joint of the foreleg (fig. 19). More of the rear flank and lower rib can be left on the breast to make shorter chops by running the line higher at the rear, but the cut across the lower shoulder should be close to the joint in the foreleg so as to leave the shoulder roast as large as possible.

A full-size shoulder roast is cut off between the fifth and sixth ribs (five ribs on the shoulder). Leave all the remaining ribs on the rib cut, or rack, and cut and saw the loin from the long legs through the small of the back or just forward of the hipbones (fig. 20). The loin and rib cuts need not be separated from each other until cut into chops.

The neck can be cut and sawed off flush with the top of the shoulder for braising with the breast, or left on and roasted with the shoulder.

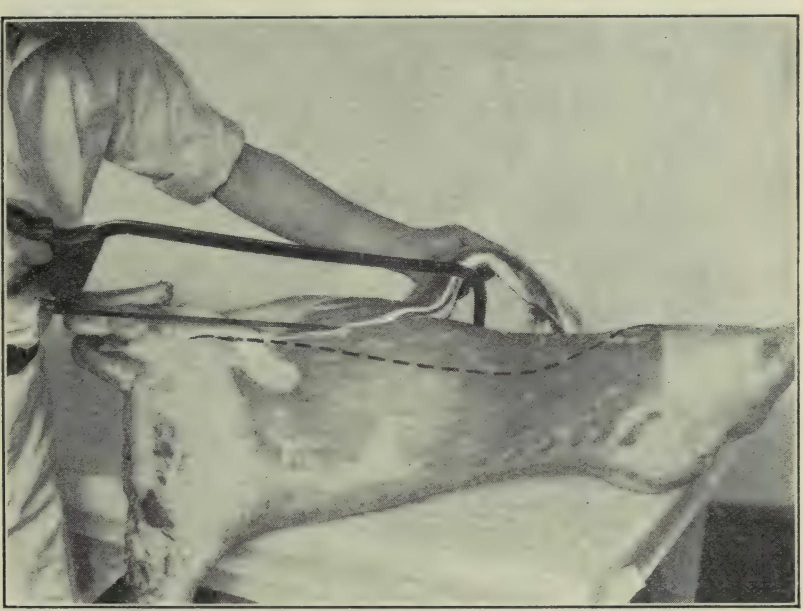

FIGURE 19.—The first step in cutting a lamb carcass—removing the breast. This carcass has been cut for long chops. If the cut had been made along the dotted line there would have been a larger proportion of breast and shorter chops.

SPLITTING THE CARCASS

The whole carcass may be split down the center of the backbone with a saw before cutting. The beginner, however, will find it easier to divide the carcass into the "wholesale" cuts first, splitting each cut separately (fig. 21). When only one side of the breast, a single leg, or a shoulder is needed at a time, it is probably best to remove only the desired cut, allowing the remainder of the carcass to hang in chilled storage.

TRIMMING LAMB CUTS

The breast can be cut into medium to large pieces for stewing. Small pieces of sharp bone may be kept out of the stew by careful cutting and by using the saw instead of the cleaver for the bones.

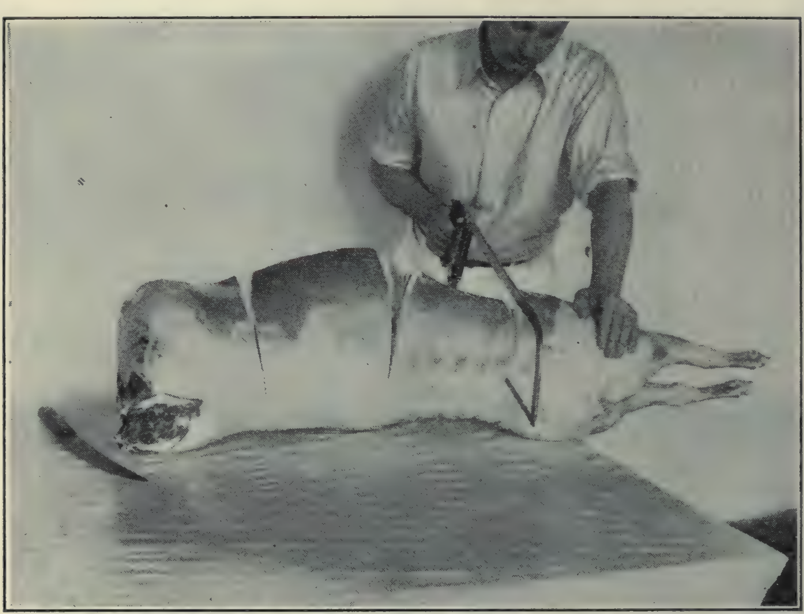

FIGURE 20.—Making a five-rib shoulder, a regular rib cut, loin, and a long-cut leg. Note that the breast and neck have been removed.

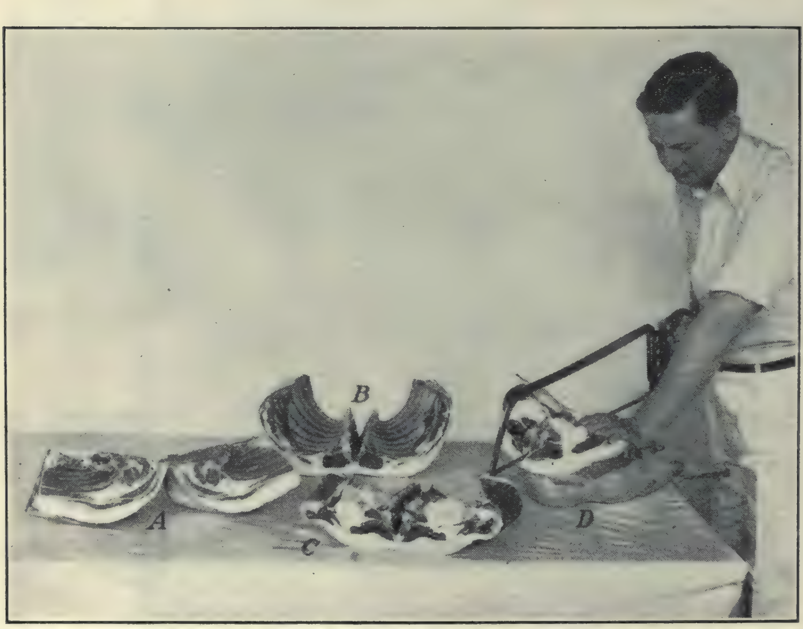

FIGURE 21.—Splitting the cuts down the center of the backbone. The cuts shown are, (*A*) shoulders, (*B*) ribs, (*C*) loins, and (*D*) legs.

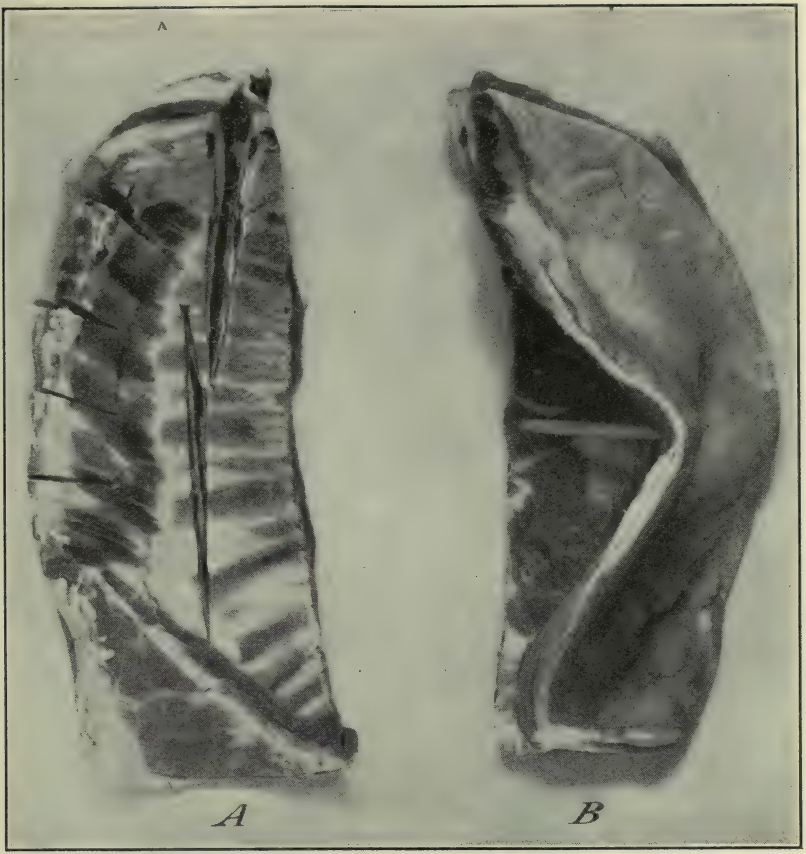

FIGURE 22.—*A,* Breast of lamb prepared for braising; *B,* a similar cut opened for a pocket roast.

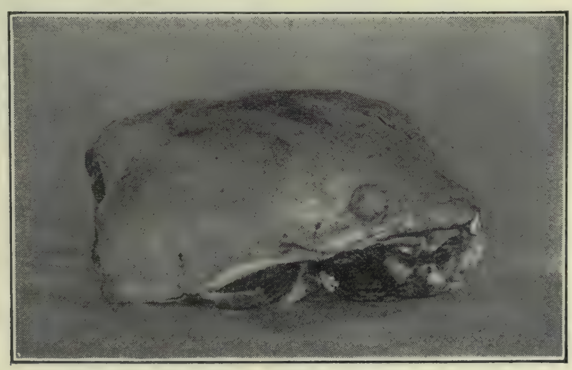

FIGURE 23.—Cushion style, boneless shoulder roast.

The breast may also be boned and rolled or made into a pocket roast and stuffed with the ground flank or other dressing (fig. 22).

Each shoulder will yield two or three rib chops and one or two shoulder chops if sliced along the rib and across the lower or arm side. The remainder of the shoulder may be too small to roast but can be added to the stew. The full-cut shoulder makes an excellent roast. If boned (fig. 23), it is easy to carve and compares favorably with the more popular leg.

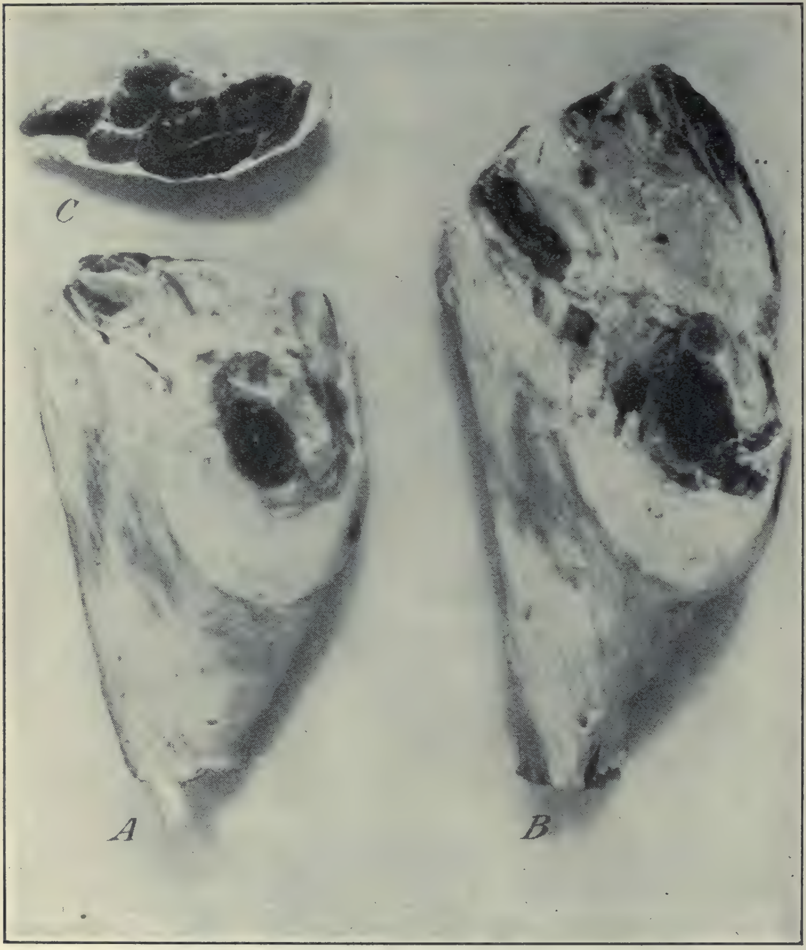

FIGURE 24.—Two methods of trimming a leg of lamb for roasting: *A*, French method with chops (shown at *C*) removed; *B*, long-cut leg.

The legs are trimmed smooth by removing the flank muscle and excess fat and cutting off the shank about where the tendons enter the meat. The forward end of the long-cut leg may be trimmed further by cutting off two or three chops (fig. 24).

The rib cuts also may be used for roasts or made into chops (fig. 25) by slicing between the ribs and cutting the backbone with a saw, cleaver, or heavy knife.

As previously mentioned, the quality of the meat depends, in part, on the degree of finish of the animal at the time of slaughter. Chops from a lamb that has not been fattened will have very little fat on the outer edge, as shown in the rib cut at the left in figure 26, while meat of a higher quality may be obtained from a well-bred, well-fattened lamb (fig. 26, right). Although the higher-quality ribs are more desirable, either type should prove acceptable if prepared properly.

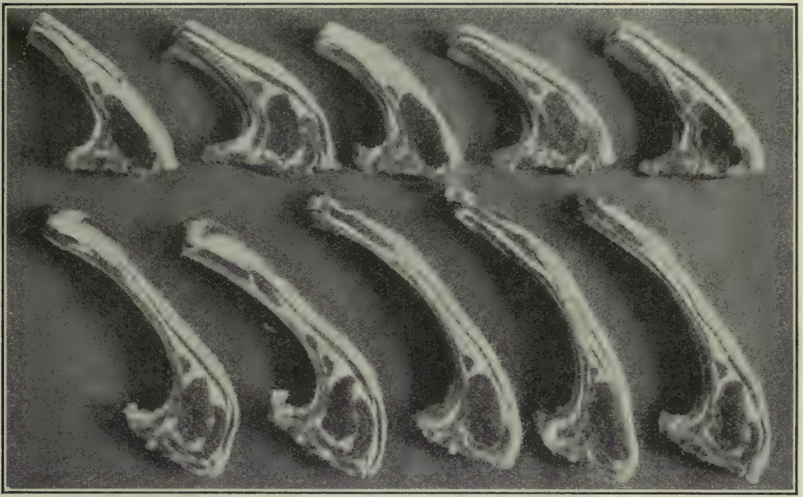

FIGURE 25.—Two types of lamb chops obtained by different methods of cutting the carcass. The short chops, in the top row, are the result of cutting along the dotted line shown in figure 19. The long chops, in the lower row, are from a carcass cut as in figure 19.

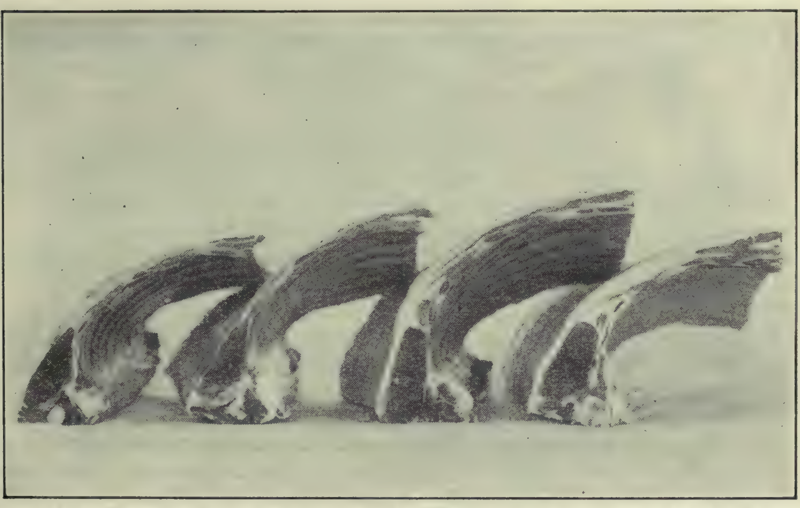

FIGURE 26.—Illustrating the different quality of lamb ribs. The rib cut at the left is from a lamb that was not well muscled or fattened. The next cut has slightly more meat and fat and the third still more. The cut at the right is from a well-fattened lamb and shows a larger development of muscle tissue.

The loin cuts are made into chops by first splitting the backbone down the center and then slicing the chops crosswise of the bone. The chops are cut usually ¾ to 1 inch thick. The loin chops correspond to the T-bone steaks from a beef carcass. Double, or English, loin chops are made from a loin which has not been split down the backbone.

The fell, or paperlike outer membrane, is removed from each rib or loin chop by starting at the lower end. This membrane peels off more easily when the chop is dry and cold than when it is moist and warm. The main reason the fell is removed from chops is that it becomes disagreeably hard in frying. However, the fell is left on the shoulder and leg roasts as it prevents the evaporation of some of the meat juices, thus causing the roast to cook more rapidly. Clean fell on roasts or chops or stew meat will not affect the flavor of the cooked lamb.

Lamb trimmings or the boned breast, neck, or shoulder may be ground and made into a meat loaf or patties. About one-fourth pork ground with the lamb is sometimes preferable to lamb alone.

PRESERVING THE MEAT

When lamb is to be kept longer than 2 or 3 weeks the chilled storage of a refrigerator or pantry will rarely be satisfactory. The meat must be frozen, canned, or cured.

FREEZING

Frozen lamb has been kept satisfactorily for 6 months or longer. The chilled, ripened, trimmed cuts are carefully wrapped in a good grade of parchment or other paper that has been treated so as to make it moisture proof. Care is needed to fit the paper tightly against the meat, especially along the exposed surfaces of lean. This protection of the meat from air and evaporation during freezer storage will add to its keeping qualities. Pieces of parchment paper should be placed between the chops or cuts that are wrapped in the same package to keep those pieces from freezing together. Tie and label the packages of meat and spread them for prompt freezing. The frozen meat may then be piled or boxed for storage in the freezer.

Temperatures of 10° F. or lower are used successfully for storing frozen lamb. A temperature of 0° or −10° is probably better than higher ones for freezing lamb.

For best results, thaw frozen chops before putting them into the pan to cook. Stew meat can be put into the kettle without previous thawing. Roasts will cook more uniformly and in less time if thawed first. Refrigerator temperature is preferable to room temperature for thawing, although either may be used. Thawed meat is likely to spoil more quickly than fresh meat. Thawed meat is normally rather moist and should be cooked promptly before the bacteria that are usually present on the surface have a chance to develop and cause spoilage.

CURING

Lamb is easily and quickly cured, but there is the disadvantage that the cuts dry rapidly after smoking and tend to become strong in flavor. Ribs, loins, and breasts that have been cured and smoked may become disagreeably dry and strong in flavor after only 3 or 4 weeks in storage. Smoked legs store better than shoulders, but even legs will become fairly dry and hard after 2 to 4 months' storage at room temperature. Some families prefer the "gamey" flavor of cured lamb and cure several cuts for special use. Freshly smoked lamb may be boned and canned in the pressure cooker by those who wish to prevent the meat from drying.

Salt is used in curing to preserve the meat, sugar to improve the flavor, and saltpeter to set the red color in the muscle tissue. Salt alone will cure the meat, but most people prefer the so-called sugar cure consisting of salt, sugar, and saltpeter. Meat to be cured should be from carcasses that have been promptly chilled to a temperature of about 36° F. The standard temperature is from 36° to 38° for the meat, for the curing mixture, and for the curing room throughout the curing period. If the temperature of the pack rises above 40° during curing there is some danger of spoilage. Temperatures of approximately 32° or below retard or stop the curing process.

Chilled lamb is normally put in cure while quite fresh, or within 1 or 2 days after slaughter. If frozen, it should be thawed, in air or water, before being packed down in cure. It should be kept from freezing before it is salted. Split the rib cuts, loins, and other pieces down the center of the backbone and remove the spinal cord before the meat is put in cure. The soft cord spoils easily.

BRINE METHOD

There are several different recipes for sugar-curing lamb by the brine method. A standard formula, used also for curing pork, calls for 8 pounds of salt, 2 pounds of white or brown sugar, and 2 ounces of saltpeter. The mixture is dissolved in 6 gallons of cold water, which makes a mild brine. Pack the chilled, trimmed meat carefully and closely in a clean crock or well-scalded, odorless hardwood barrel and pour in the cold (36° to 38° F.) brine until the pack begins to shift and float. When the brine has reached all surfaces of the meat, use a clean, hardwood board and a clean stone to weight down the meat. Cover the pack well with the brine.

Six gallons of brine should cover 100 pounds of meat. If the size or shape of the container or the loose packing of the meat makes 6 gallons insufficient, more brine should be made and used to submerge the meat.

Overhaul the meat on the third to fifth day. This means to remove the meat from the brine, pour out the pickle, repack the meat, and recover with the same brine. Overhauling serves to remix the brine and to shift the meat so that all pieces will be exposed to the brine.

The thin cuts, such as the breast, ribs, and loins, should be sufficiently cured, even in this mild brine, in 10 days to 2 weeks, depending upon their size. Legs and shoulders will require a second overhauling when the thin cuts are removed and should stay in cure from 25 to 40 days. Legs weighing from 5 to 6 pounds should be ready for smoking in 30 to 35 days.

If the brine becomes sour or ropy, and the meat is still sound, remove the meat and scrub it in hot water, wash and scald the container, boil, skim, and cool the brine, and pour it back on the meat. It would be safer to make new brine and discard the old.

DRY METHOD

A 5-4-4 curing mixture has been used successfully for dry-curi lamb. This mixture calls for 5 pounds of salt, 4 pounds of suga and 4 ounces of saltpeter for each 100 pounds of lamb. Mix t ingredients thoroughly, sprinkle a little of the mixture on the botto of the clean container, and rub and pat the proportionate amou on each piece of lamb, fitting the pieces carefully into the pac Apply about two-thirds of the mixture the first time, the remaini third being used when the meat is overhauled 3 to 5 days later. T meat may be left in the cure until used or may be removed f smoking on the same schedule given for the brine cure.

SMOKING CURED LAMB

Scrub cured lamb thoroughly with hot water and a stiff brush a hang it up to drain and dry. It may be exposed to hardwood smo for about 2 days at a temperature of 100° to 120° F. in the sam manner as cured pork. The meat may be removed from the smok house as soon as it is satisfactorily colored, or left in for longer intermittent smoking, if desired.

STORING CURED LAMB

If smoked lamb cuts are to be stored at ordinary room temperatur for several months, they should be cooled and wrapped in paper a muslin, the same as is customarily used for pork. Attention is calle again to the fact that cured lamb dries rapidly, particularly t thinner cuts.

CANNING

A satisfactory method of preserving lamb is by canning. Metho for canning lamb in the pressure cooker are described in Farmer Bulletin 1762, Home Canning of Fruits, Vegetables, and Meats, pr pared by the Bureau of Home Economics.

PRESERVING LAMB PELTS

Lamb pelts to be preserved may be hung over a board or wir skin side out, to cool and dry. They may also be spread on the floo wool down, and salted. Care should be taken to put salt on the edge legs, and head portions. Salted pelts may be piled on top of on another, all pelts fleece down. Pelts will be cured in from 15 to days.

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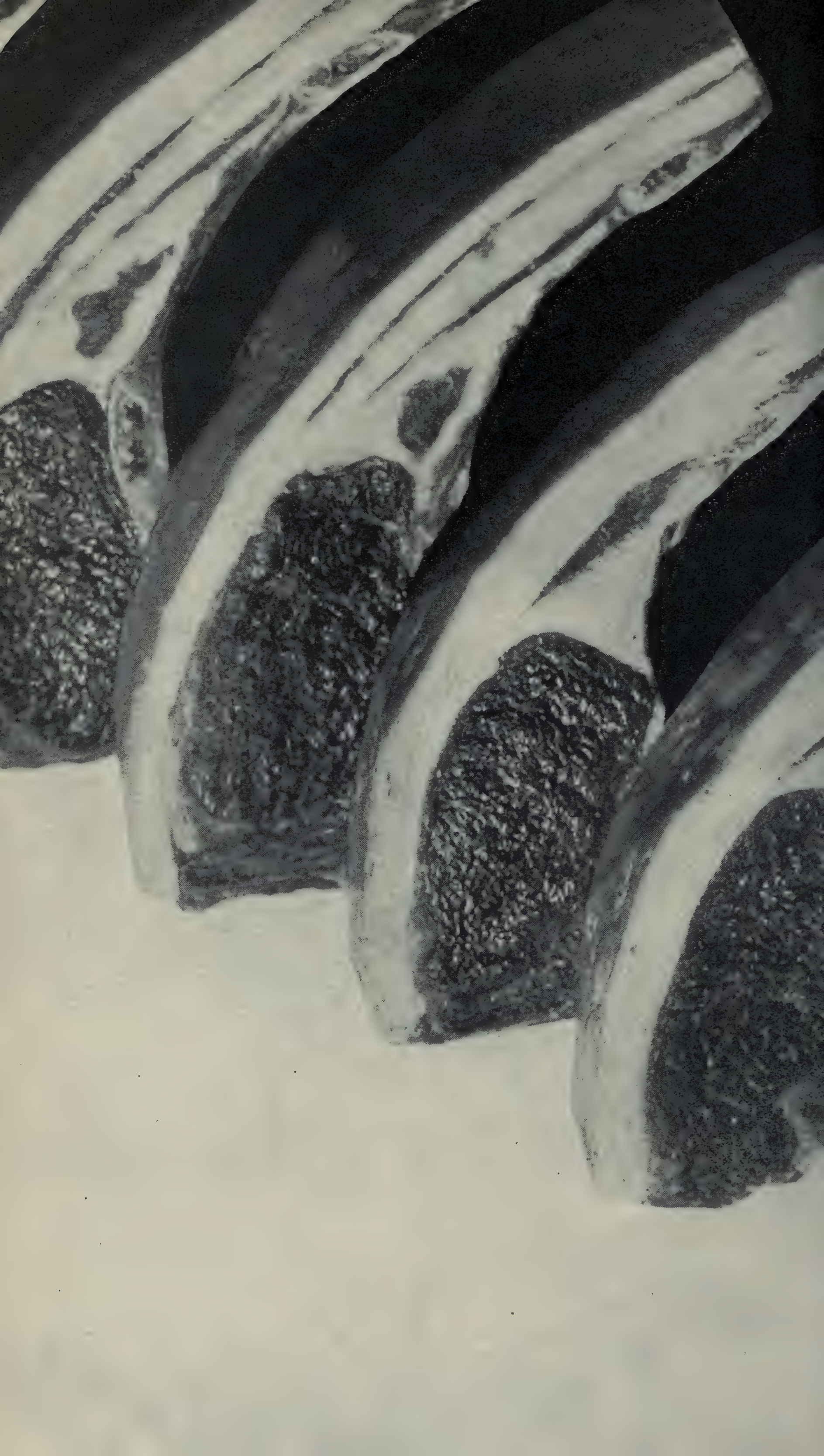

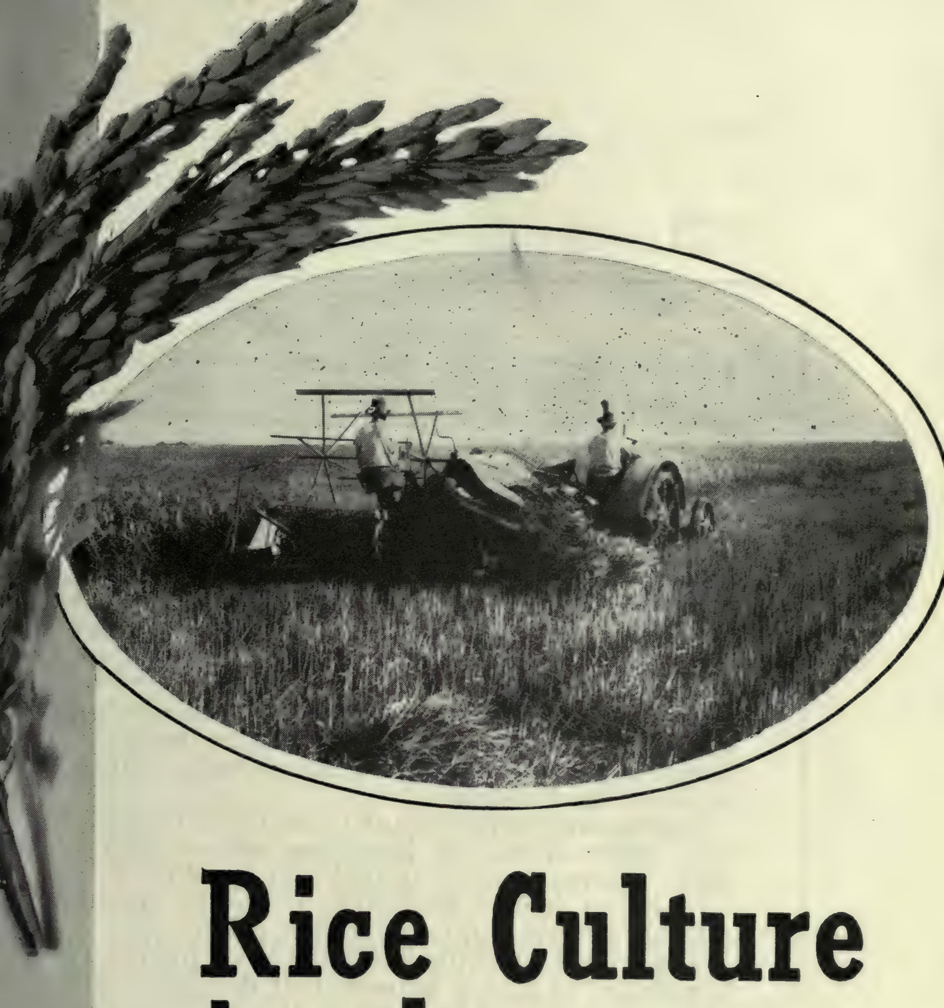

Rice Culture in the Southern States

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RICE is the principal cash cereal crop grown on the prairies of southwestern Louisiana, southeastern Texas, and on the Grand Prairie of eastern Arkansas. The crop is grown on relatively level heavy soils that hold water well and that, with reasonable cost, can be prepared for irrigation and provided with fairly good surface drainage. About 42 million bushels are grown annually in the United States.

A dependable and adequate supply of fresh irrigation water is necessary for successful rice culture. This water is obtained from streams that pass through the prairies, or from wells.

The levees, which divide the field into subfields, should be well constructed on contours and of sufficient height to hold an average depth of 5 inches of water on the land.

Rice is sown between April 1 and May 15, usually with grain drills; but broadcast seeders also are used. Normally there is sufficient moisture in the seedbed to induce germination and to maintain seedling growth until the land is submerged.

The crop is promptly harvested when mature and is shocked in such a manner that the grain, while curing, is protected as much as possible from exposure to the sun and rain. The rice is threshed after it has cured in the shock from 10 days to 2 weeks. The threshed grain is stored on the farms or in public warehouses until sold to the rice mills, in which it is prepared for market.

This bulletin supersedes Farmers' Bulletin No. 1092, Prairie Rice Culture in the United States.

Washington, D. C. **Issued October 1938**

RICE CULTURE IN THE SOUTHERN STATES

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INTRODUCTION

RICE (*Oryza sativa* L.) is the principal energy food of a large part of the population of China, India, the Japanese Empire, Indo-China, Siam, the Dutch East Indies, the Philippine Islands, Malaya, and Madagascar. About 97 percent of the world's annual rice crop is produced in the Far East. The principal producing countries in the temperate regions are Italy, the United States, Spain, Brazil, and Egypt.

The per capita consumption of rice in the continental United States is about 6 pounds a year, whereas in India, Chosen, French Indo-China, Java, Madoera, and the Philippines it is over 200 pounds, and in Japan proper, Taiwan, and Siam, from 300 to 400 pounds.

HISTORY

Rice probably originated somewhere in the area extending from southern India to Cochin-China. Its cultivation appears to have spread from this region northeastward to China, possibly as early as 3,000 years before the Christian era, and more recently west and north through India to Iran (Persia), Arabia, Egypt, and ultimately to Europe.

Rice was introduced into the colony of South Carolina at or near Charleston, probably from Madagascar, about 1685. The acreage sown in South Carolina increased rapidly, and the crop soon moved into North Carolina and Georgia. About 1718 it was introduced int Louisiana. In 1859, South Carolina, North Carolina, and Georgi produced about 90 percent of the rice grown in the United State and South Carolina alone produced about 60 percent of that grow Rice growing in the South Atlantic States was affected adversely b the Civil War, and production declined thereafter. About this tim the rice acreage increased along the Mississippi River in Louisian However, the crop did not become very important in Louisiana unt 1887, when it was determined that rice could be grown profitably b machine methods on the prairies in the southwestern part of t State. In 1889 Louisiana became, and still is, the leading State i rice production.

Upland or nonirrigated rice probably was grown to a small exte in Texas as early as 1863; however, the crop did not become of com mercial importance on irrigated land until 1899, when some 8,50 acres were grown in the Beaumont district of Jefferson County, i southeastern Texas. The successful production of rice on the nearb prairies of southwestern Louisiana no doubt had a stimulating effe on the development of the industry in Texas.

In 1902 rice was grown on a limited scale on the Grand Prair of Arkansas near Lonoke. In 1904 over 400 acres were grown, an commercial production began the following year.

In California the first commercial rice crop was grown near Bigg in the Sacramento Valley, in 1912.

The first crop of rice in the upper Mississippi Valley was grow near Elsberry, Mo., in 1923. The high yields and high prices obtaine for this crop resulted in a rapid extension of the rice acreage in t Elsberry district, and by 1928 over 10,000 acres were sown. In th district, however, the decline in the rice acreage following 1928 w even more rapid than the increase had been, and by 1930 practically commercial rice was grown. The sudden collapse of the new industr was largely brought about by a decline in yields and the poorer qualit of the rice, due to (1) a shortage of irrigation water and facilities f irrigation; (2) poorly constructed canal and field levees; (3) inade quate surface drainage; and (4) failure to rotate rice with other crop Practically no commercial rice is now grown in Missouri, but rel tively high yields have been obtained in the cooperative experimen at Elsberry Field, Elsberry, Mo.

The commercial rice crop of the United States is now grown almo entirely in the States of Arkansas, California, Louisiana, and Texa

RICE-PRODUCING SECTIONS

The three principal rice-producing sections in the United Stat are: (1) The broad level prairies of southwestern Louisiana and sout eastern Texas. Irrigation water for this section is largely pumpe from sluggish streams or bayous, which provide natural drainage f the prairies; however, wells also provide water for irrigation. Th is the most important rice-producing section of the United States.

(2) The Grand Prairie section of eastern Arkansas. Irrigatio water for this section is largely pumped from wells.

(3) The Sacramento and San Joaquin Valleys of California. I these valleys irrigation water is obtained by diversion or pump largely from the Feather and Sacramento Rivers.

The methods of production in California differ materially from those used in the Southern States, and since Farmers' Bulletin 1240, How to Grow Rice in the Sacramento Valley, is available, which deals with the methods of production in California, this bulletin, except for information regarding the importance of the rice crop, is confined largely to the conditions under which rice is grown in the Southern States and the methods of production used there.

IMPORTANCE OF THE RICE CROP

In the United States the acreage on which rice crops can be grown successfully is much more limited than the acreage adapted to other cereals. Rice, however, is well adapted to certain sections of Arkansas, California, Louisiana, and Texas on which other cereals cannot be grown successfully, owing largely to excessive moisture and high temperatures. In many counties and parishes of these four States rice is the principal cash crop grown (fig. 1).

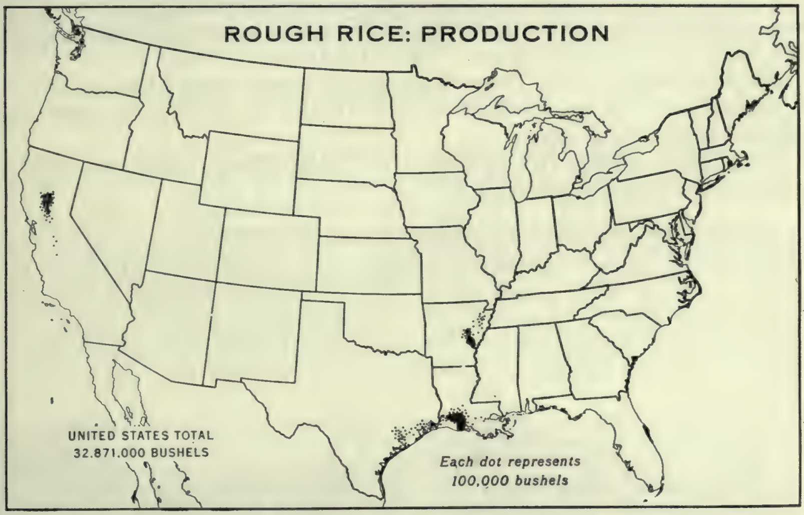


FIGURE 1.—Rice production in 1935. Each dot represents 100,000 bushels.

Louisiana produces about 40 percent of the commercial rice crop grown in the United States, and Arkansas, Texas, and California produce about 20 percent each.

REQUIREMENTS OF THE CROP

CLIMATE

In the United States the production of satisfactory rice crops is dependent upon (1) high temperatures, especially relatively high mean temperatures, during the growing season; (2) a dependable supply of fresh water for irrigation; (3) soils that are comparatively level and hold water well because of a tight soil or subsoil through which loss by seepage is small; and (4) good surface drainage.

These conditions prevail to a large extent on the coastal prairies of southwestern Louisiana and southeastern Texas and on the Grand Prairie of Arkansas. In these sections the summers are hot and sultry, and the daily maximum temperatures usually range from 90° to 100° F. or above, and the mean temperatures in late spring and early fall are about 70° and in summer about 82° or above. The average annual precipitation ranges from about 36 to 56 inches and is well distributed during the growing season. For this reason less irrigation water is required to produce a crop than if the summer rainfall were low.

SOILS

Rice can be grown on all types of soils, but the crop normally is grown only on medium to heavy soils, which are more economical in the use of water and, when drained, support harvesting machinery better than do lighter soils. In Louisiana and Arkansas a good deal of rice is grown on Crowley silt loam, which holds water well. This soil is rather heavy and compact and when plowed wet is likely to puddle. Rice is also grown in these States on lighter soils underlain by relatively impervious subsoils.

In southeastern Texas, Lake Charles clay is a typical rice soil. It is rather plastic and sticky when wet and is more difficult to cultivate than Crowley silt loam. Lake Charles clay and other soils on which rice is grown in Texas may puddle and then bake on drying, if plowed wet. A better seedbed is obtained if plowing is done when puddling does not occur.

The soils on which rice is grown in the Southern States usually are deficient in organic matter.

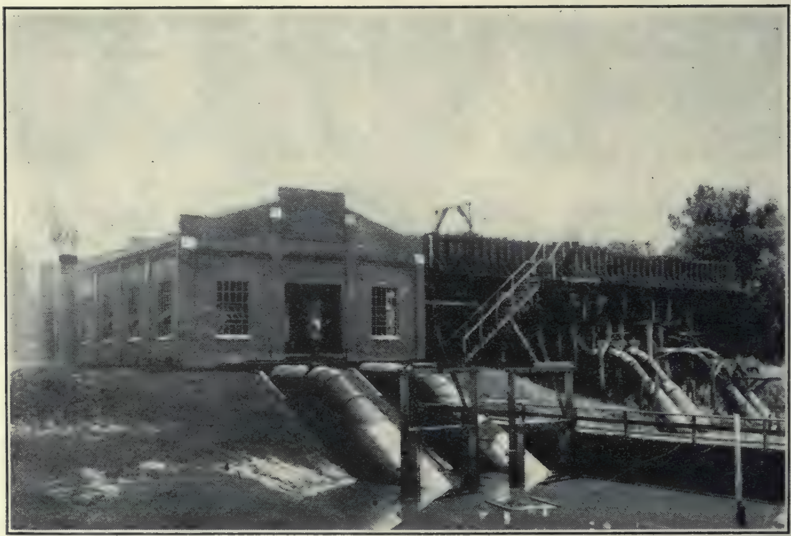
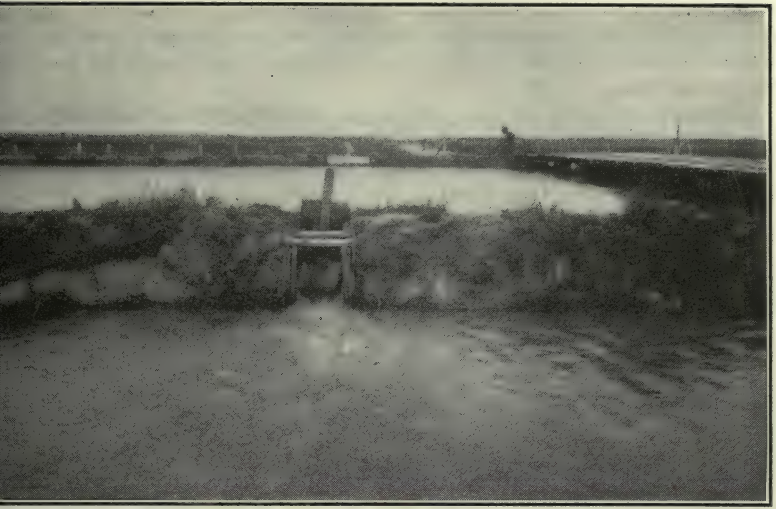


FIGURE 2.—Intakes for modern irrigation pumps.

SOURCES OF IRRIGATION WATER

Irrigation water for rice production on the prairies of Louisiana and Texas is obtained largely from the sluggish streams that pass through the prairies en route to the Gulf of Mexico. The water is lifted from the streams by pumps and is distributed in surface canals by privately owned companies (figs. 2 and 3). In this region, how-



RE 3.—A floodgate through which water passes from the main irrigation canal into smaller canals and then into the fields.

r, considerable irrigation water is also obtained from wells. In
e wells near the Gulf, water stands near the surface of the ground,
away from the Gulf it is sometimes 35 or 40 feet below the sur-
e. There are sufficient wells in this region to irrigate, if necessary,
m 30 to 40 percent of the rice acreage in Louisiana and probably
m 15 to 20 percent of that sown to rice in Texas (fig. 4). The
ls are owned by the farmers, and while most of them are operated
h year others are used only in case of a shortage of fresh water
he canals. It requires about 48 inches of water to produce a crop

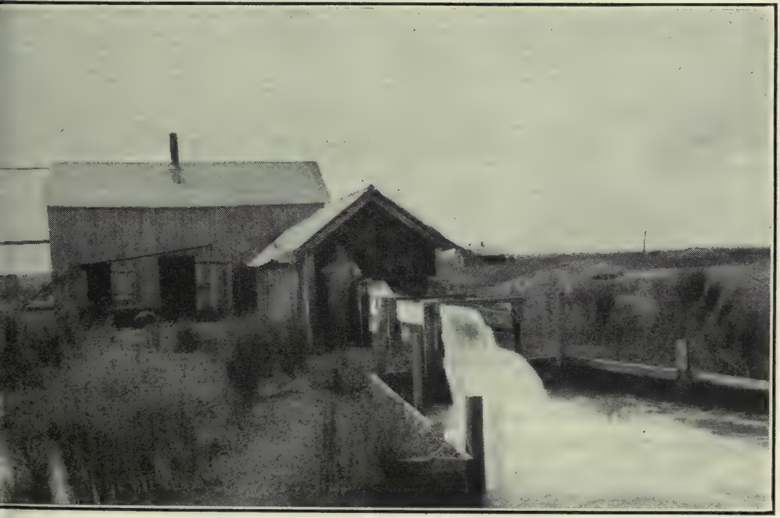


FIGURE 4.—Water being discharged from a well.

in this region, of which about 20 inches are supplied by rainfall d ing the growing season. The charge for water supplied by ca companies varies from year to year, but ranges from $6 to $9 acre per season.

In Arkansas most of the irrigation water is obtained from w owned by individual farmers. The water level ranges from 25 60 feet below the surface of the ground. The capacity of the pun used depends upon the acreage to be irrigated and the lift. T minimum capacity of the pump should not be less than 5.6 gall per minute per acre. The cost of pumping water usually ranges fr $6 to $10 per acre per season. It requires from 24 to 30 inches water to produce a rice crop on normal soils of the Grand Prai of which about 6 inches is supplied by rain during the grow season.

PREPARATION OF LAND FOR IRRIGATION

Most of the land on which rice is grown in the Southern States comparatively level, with a gentle slope toward drainage chann The preparation of such lands for irrigation is usually not very pensive. A competent surveyor should be employed to locate supply and drainage ditches and the field levees. The improper lo tion of ditches and levees may cause serious losses, owing to fau irrigation and poor drainage. The irrigation ditches should be la enough to supply ample water promptly when needed, and the dra age ditches should likewise have sufficient capacity to dispose of water promptly when desired. The levees that divide the field i subfields should be permanently located on contour lines. Th should be spaced so that the water in the subfields can be held at average depth of 4 to 6 inches. The levees should have gently sl ing sides and be high enough to hold an average depth of 6 inc of water on subfields without overflowing into the next lower s field (figs. 5 and 6). Farm machinery can pass readily over lev of this type without damage to them or the machinery. Slopi levees reduce the cost of seedbed preparation, of seeding, and harvesting, for each field can be worked as a unit. Levees of t type are also seeded and often produce considerable rice, there reducing the growth of weeds. If high, narrow levees are used, ea subfield usually must be prepared for seeding, seeded, and harves separately.

Compact levees reduce seepage. Levees should be constructed a repaired, if possible, during the winter months, so that they will ha time to settle before irrigation begins. All newly constructed lev settle considerably and should be built nearly twice as high as necessary to hold the water at the desired level. Well-construc levees facilitate irrigation and make it unnecessary to do much pensive hand-shoveling when the fields are submerged.

Irrigation water normally is delivered by ditches, canals, pumps to the highest subfields in a field, and it passes into succ sively lower subfields through openings in the levees. The op ings in the levees are closed when the desired depth of water is tained in the field. Some fluctuation in the depth of water held ce fields is almost unavoidable, owing to variations in the irriga-on water supply and in rainfall.

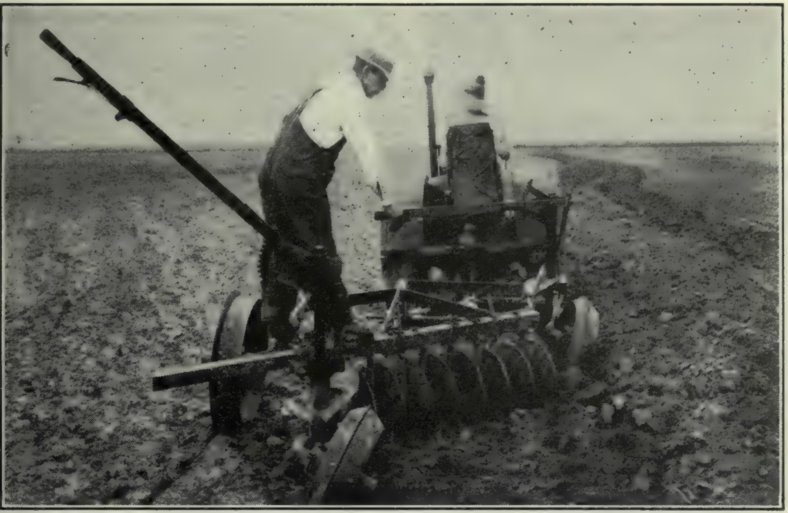


FIGURE 5.—Constructing a levee with a disk plow.

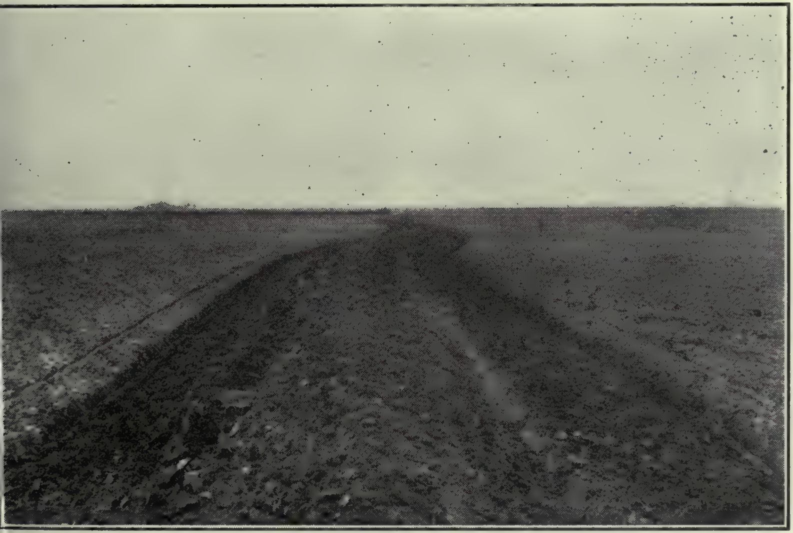


FIGURE 6.—A levee partially constructed with a disk plow.

ROTATION

Rice is grown under conditions that make it difficult to follow a finite system of crop rotation. In order to grow cultivated crops nveniently in rotation with rice the levees usually are broken down and then reconstructed for the following rice crop, and this invol considerable expense. Furthermore, cultivated crops often are n profitable.

Rice, however, is not grown continuously on the same land. T most common practice in Louisiana and Texas is to grow one or mo rice crops, then pasture the land for 1 to 3 years before using it f rice again. The land is materially improved in physical conditi by the accumulation of organic matter on the surface during t period it is grazed. Rice soils, as a rule, are deficient in orga matter because the high temperatures and available moisture le to a rapid decomposition of organic materials incorporated in t soil. For this reason a rotation of rice and pasture appears to the best cropping system (fig. 7).

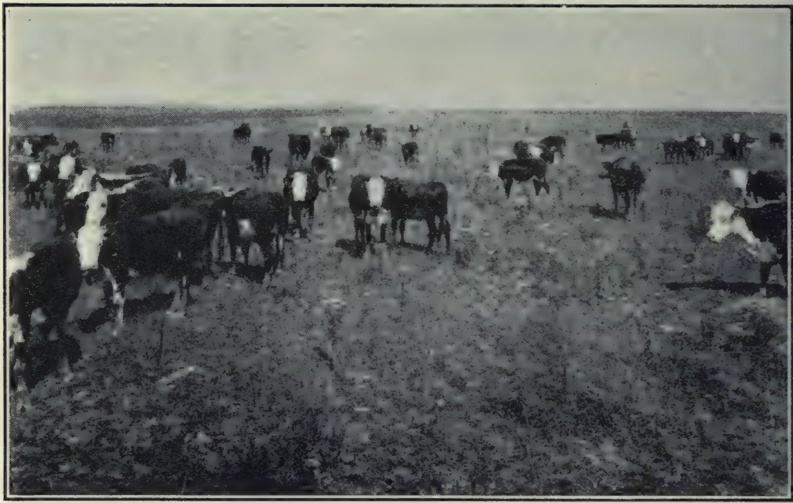


FIGURE 7.—Cattle grazing on rice-stubble land.

Rice is also grown in Louisiana and Texas in rotation with cle fallow, cotton, soybeans, corn, and green-manure crops. Fallowi is a more common practice than the growing of crops.

In Arkansas only a small portion of the resting riceland is pa tured. Much of it is simply allowed to lie idle; the remainder planted to soybeans, is fallowed, or is planted to corn, cotton, green-manure crops, which rank in importance in the order listed.

PREPARATION OF THE SEEDBED

In the preparation of a seedbed for rice the aim should be destroy weeds and obtain a mellow, firm surface layer in which t rice can be sown to the desired depth under conditions that a favorable for quick germination and normal seedling developme The land should be plowed 4 to 6 inches deep in the fall, winter, spring (fig. 8). Fall- and winter-plowed land is normally left un the following spring. If the land is reasonably well drained, t frost and winter precipitation mellow the plowed soil, and usua y spring a good seedbed can be prepared by disking, harrowing, nd floating (fig. 9). On poorly drained land more difficulty is xperienced in preparing a suitable seedbed, and replowing may be

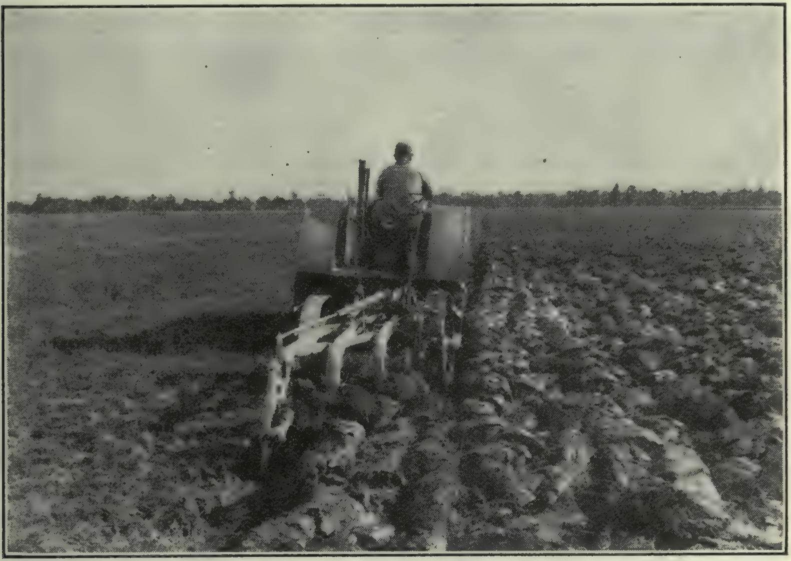


FIGURE 8.—Plowing land for rice.

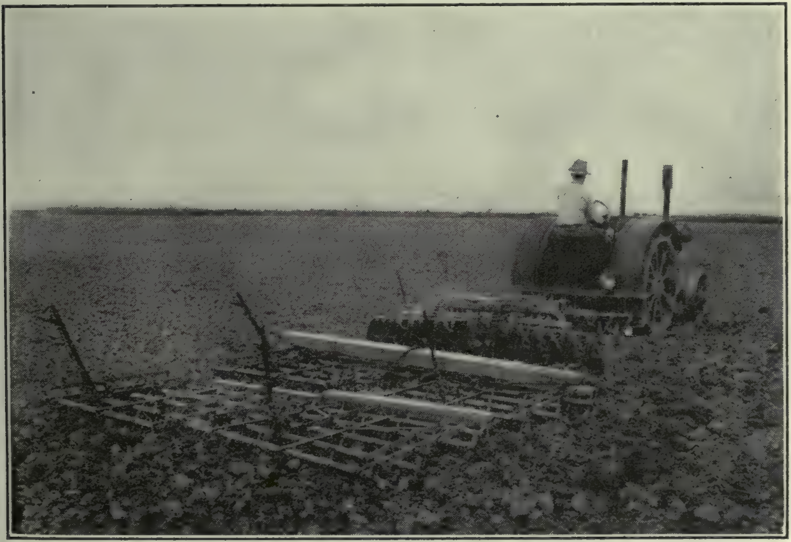


FIGURE 9.—Preparing a seedbed for rice.

ecessary. Rice stubble and weed growth plowed under in the fall nd winter decompose readily, thus facilitating the preparation of good seedbed. The land may be floated before disking, to break lods and to fill in holes. The number of times it will be necessary to disk and harrow depends upon the drainage and the conditio of the soil.

Spring-plowed land ordinarily should be disked and harrowe immediately after plowing, to prevent baking and subsequent diff culty in seedbed preparation. Heavy soils, when spring-plowec usually require more subsequent tillage to obtain a good seedbe than when plowed in the winter, but light soils are prepared easil after either winter or spring plowing.

In Louisiana and Texas early fall and winter plowing of ricelan is common, but in Arkansas most of the land is spring-plowed. I Louisiana the land may be disked in January and February, i weather conditions are favorable.

In a good seedbed the surface soil is reduced to a mellow, fir condition, moisture is held near the surface, and germination usuall occurs after seeding without requiring irrigation.

VARIETIES NOW GROWN

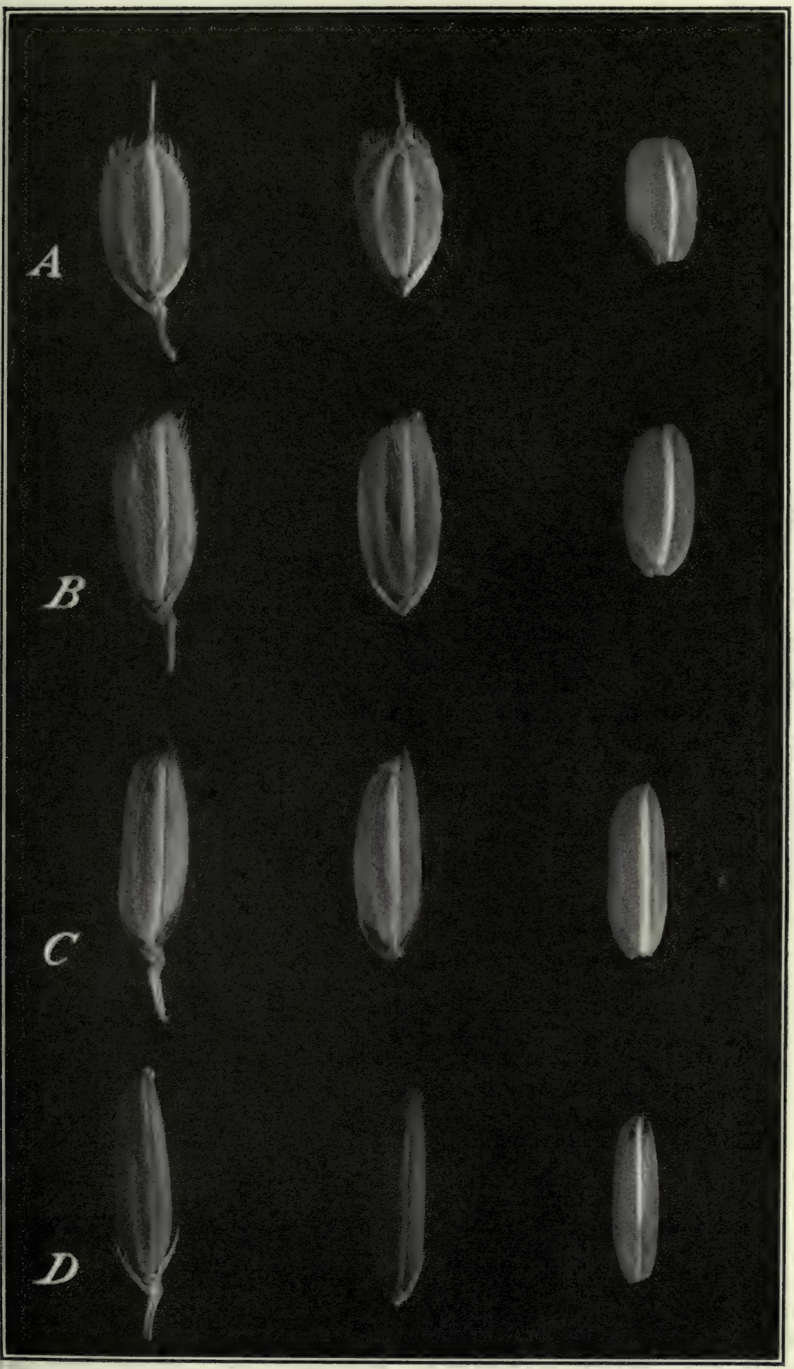
In the principal rice-producing countries of the world, varieti are often classified as lowland (irrigated) and upland (nonirr gated). Lowland (irrigated) varieties can be grown without irrigation, but under such conditions are less productive than when grow with irrigation. Upland (nonirrigated) varieties, when grow under irrigation, usually are more productive than when grow without irrigation, but are less productive than the better lowlan varieties. The words "lowland" and "upland" do not refer especiall to elevation, for lowland varieties are grown on terraced hillsides a well as on lowlands and upland varieties may be grown withou irrigation on uplands and lowlands.

In the commercial rice-producing sections of the Southern State only the lowland or irrigated varieties are grown. The varieti grown include short-, medium-, and long-grain types, which var in height from 36 to 58 inches at maturity. The average length o the kernel (hulled rice) of the short-grain rice is about 5.5 mill meters, that of the medium grain about 6.6 millimeters, and tha of the long grain about 7 to 8 millimeters (fig. 10). One millimete is equal to about one twenty-fifth of an inch.

When sown between April 15 and May 15, the varieties grown i the Southern States may be classed as early, midseason, and lat The early-maturing varieties require about 120 to 129 days from seeding to maturity, the midseason varieties about 130 to 139 days, an the late-maturing varieties 140 days or more.

The number of days required from seeding to maturity varies wit the date of seeding. Rice sown relatively early in the spring r quires a longer time to mature and usually produces higher yiel than that sown late. All varieties, however, do not have the sam capacity to shorten the length of the growing period when sown lat For example, at Crowley, La., Blue Rose, when sown March 15, matures in about 189 days; but when it is sown May 15 it matures i about 135 days, or a difference of 54 days, whereas Early Prolifi sown on the same dates, matures in 141 and 122 days, respectively, o a difference of only 19 days.

Varieties that materially lengthen or shorten their growing period when sown from early to late in the spring include Blue Ros



GURE 10.—Spikelet, seed, and kernel of (*A*) Caloro, short grain; (*B*) Blue Rose, medium grain; (*C*) Furtuna, long grain; (*D*) Rexoro, long slender grain rice.

Wataribune, Acadia, Caloro, and Honduras. Varieties that sho much less variation in the length of the growing period when sow from early to late in the spring include Early Prolific, Fortun Delitus, Rexoro, Nira, and Iola.

Varieties, such as Blue Rose, that have a tendency to mature nearly the same date regardless of the date of seeding are not we suited for growing on a large acreage, because the entire crop is likel to be ready for harvest at about the same time. Such varieties, hov ever, are well suited for late seeding. Varieties, such as Early Pr lific, Rexoro, etc., can be used to advantage on large acreages, b cause they mature relatively early if sown early and later if sow late. Hence, the harvest period can be extended over a longer peric by seeding at different times. These varieties, however, are not we suited for late seeding.

SHORT-GRAIN VARIETIES

The short-grain rice varieties grown in the Southern States ar of Japanese origin and are fairly well adapted for growing on th prairies of the South as well as in California. They are hardy an produce relatively high field yields of good milling quality. Yea ago these characteristics tended to make them popular with bot farmers and millers. Now, however, medium- and long-grain vari ties are preferred by the growers and the consuming public.

The leading short-grain rices grown are Wataribune, Acadia, an Shinriki, which, when sown during the normal seeding period, a late maturing, and Caloro, an early or midseason variety. Only small part of the total commercial acreage in the three Southe States, however, is sown to this type of rice. During the 3-year peric (1933–35)[1] only 0.1 percent of the rice produced in Louisiana co sisted of short-grain varieties, but in the same period 2.30 perce of that produced in Texas and 6.30 percent of that produced i Arkansas consisted of the short-grain rices.

The seeds of Wataribune, Acadia, Shinriki, and Caloro are sho and broad, and the hull is light yellow (straw) in color. Watar bune, Acadia, and Caloro are partly awned (bearded), but the aw are comparatively short and usually are broken off in threshin The leaves of these short-grain varieties are narrow, and the stall are relatively small and pliable. They tiller freely and, when grow on rich land, produce heavy panicles, the weight of which may caus the plants to lodge. They do not shatter easily. The stalks an leaves of the short-grain varieties often are fairly green when th crop is mature.

MEDIUM-GRAIN VARIETIES

Most of the commercial rice produced in Louisiana, Texas, an Arkansas consists of the medium-grain varieties Blue Rose and Earl Prolific. The seeds of these varieties are not so long as those c Edith or so short as those of Caloro. They usually yield and mi well and for this reason are popular with both rice growers an millers. Blue Rose and Early Prolific have relatively stiff stra fairly wide leaves, and when grown on reasonably fertile land tille freely and yield well. When sown during the normal seeding perio

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[1] The information on the acreage and production of varieties is based on annual da compiled by the Rice Millers Association, New Orleans, La.

Blue Rose is a late-maturing variety, and Early Prolific, as the name ndicates, is early maturing. Both varieties are susceptible to diseases nd for this reason probably are not now so productive in the South s they once were. In the 3-year period 1933–35, 92 percent of the ice produced in Arkansas, 91 percent of that in Louisiana, and 68 percent of that in Texas consisted of Blue Rose and Early Prolific.

LONG-GRAIN VARIETIES

Long-grain rice varieties are not so extensively grown in the Southrn States as are the medium-grain varieties. This probably is beause in the past the principal long-grain varieties grown did not ield so well in the field or in milling as do the medium-grain varieies. Owing to the shape of the kernels, long-grain rices are more ikely to be broken in milling than are the medium- and short-grain arieties. Long-grain varieties, however, often have commanded a premium over medium- and short-grain rices in the rough- and cleanice markets. This increase in value of the rough and clean rice has ended to make up for the loss resulting from lower field and mill ields when compared with medium- and short-grain varieties.

Honduras, an early-maturing, long-grain variety, was extensively rown for many years in the Southern States. Owing to the fact hat it is susceptible to disease and produces relatively low yields on ld land, it was largely replaced by the long-grain, early-maturing Edith and Lady Wright varieties, which are now being replaced by he later maturing Fortuna, Rexoro, and Nira varieties. These three, which have only recently been released for commercial growing, proluce higher field yields than the others mentioned, are more resistant o disease, and are also of better table quality.

In 1936, 4.27, 7.84, and 2.89 percent of the rough rice produced in Louisiana consisted of Fortuna, Rexoro, and Nira, and these varieies made up 6.59, 11.08, and 5.56 percent, respectively, of the rice produced in Texas. They are vigorous, have stiff straw and wide eaves, yield well, mill well for rices of this type, and are of good able quality. Owing to late maturity, when sown during the usual eeding period, they are best suited for growing in Louisiana and Texas, whereas Honduras, Edith, and Lady Wright can be grown qually well in Arkansas. If sown early, Fortuna and Nira also could probably be grown successfully in Arkansas. Fortuna, Rexoro, and Nira grow tall enough to bind well, tiller quite freely, and are easily hreshed even though they are rather leafy. In order to reduce shatering, these varieties should not be harvested until fully mature.

SEED AND SEEDING

IMPORTANCE OF GOOD SEED

Good seed rice should be well matured and free from red rice, immature, hulled or broken seed, seed of other varieties, and weed seeds. The seed should be cleaned well to remove hulls, trash, weed seeds, and immature seeds. Mixtures of other varieties differing in kernel size or maturity are particularly objectionable. Uniformity in ripenng and in kernel size are more important in rice than in wheat because the value of rough rice is based largely on the percentage of whole kernels obtained in milling, whereas wheat is ground into flour.

Seed containing red rice (rice with red kernel coats) should b avoided because the red grains spoil the appearance of the milled ric Seed of low germination may result in uneven stands, uneven ripening, and often in lower field yields of poor milling quality.

METHOD OF SEEDING

Rice usually is sown with a grain drill, but broadcast seeders als are used. In Arkansas most of the rice is broadcast. Of the tw methods, drilling is preferred because it places the seed at a unifor depth under conditions that are more favorable for uniform germination (fig. 11). Less seed is required to obtain maximum stands o drilled rice than of broadcast rice, but drilling is more expensive Rice often is broadcast on poorly prepared rough seedbeds in Louisiana and Texas. If rice is drilled too deep, the seedlings may hav difficulty in emerging, especially if a crust forms on the soil surfac following rains.

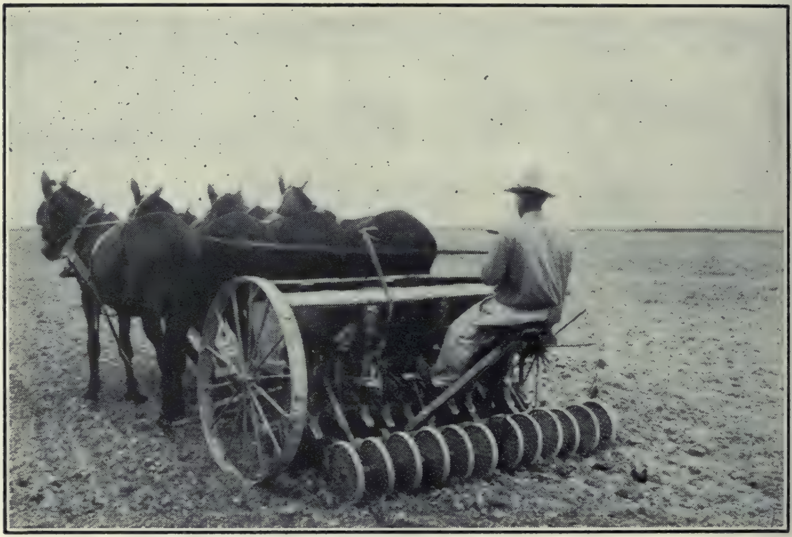

FIGURE 11.—Seeding rice with a 12-hole grain drill.

TIME OF SEEDING

Rice usually is sown in the Southern States from April 1 to Ma 15, but some seeding is done in March if conditions are favorabl Rice germinates more quickly when sown late in the spring, whe temperatures are high, than when sown early. Seed of early sow rice is more subject to rotting because of the lower temperatures an less favorable conditions for quick germination and rapid growth Under such conditions poor stands may be obtained. Late seedin also has an advantage in that the weeds that have started growth ca be killed by cultivation prior to seeding. Results from date-of-seeding experiments indicate that there is a comparatively long period i the South during which rice can be sown and still produce satisfactory yields. It is possible and, in some cases advisable, to vary th date of seeding of certain varieties, so that the harvest can be extended over a longer period.

RATE OF SEEDING

Rate-of-seeding experiments with drilled rice, under very favorable conditions, indicate that 80 pounds of seed per acre usually is sufficient to give good stands and that the yields are seldom materially increased and may be reduced if more than 80 pounds an acre is sown. Under ordinary conditions, 90 to 100 pounds of recleaned viable seed sown with a drill or 125 to 150 pounds sown broadcast is sufficient to give good stands. The rate of seeding should be sufficiently high to produce stands that are thick enough to check weed growth and also to prevent excessive tillering, which might result in irregular ripening and reduced yields of inferior quality. Less seed is required when rice is sown late than when it is sown early in the spring, for conditions are more favorable for germination late in the season. Many other factors, such as seed quality, condition of the seedbed, fertility of the soil, and the variety enter into the determination of the proper rate of seeding.

DEPTH OF SEEDING

On good seedbeds rice should be sown 1 to 2 inches deep. Usually there is less danger from rotting from shallow than from deep seeding, especially if it is necessary to flush (irrigate) the land after seeding to induce germination. Rice can be sown deeper with safety on light soils than on heavy soils. Shallow seeding is preferable to deep seeding on a rough seedbed or a fine mellow seedbed that is likely to crust following rains. Surface crusts, when they form, may be broken up by a light harrowing or by irrigation, to permit the emergence of the seedlings.

FERTILIZERS

Prairie rice soils often are deficient in phosphorus as well as in organic matter. Rice, like other crops, cannot be grown profitably on soil so deficient in nutrients that they must all be supplied as fertilizers. The best fertilizer treatment can usually be determined by tests conducted under local conditions. The results of fertilizer experiments in which nitrogen, phosphorus, and potash have been applied singly and in combinations at seeding time, at the rice experiment stations in the South, have not as a rule shown consistent or marked increases in yields.

Nitrogenous fertilizers may produce a more vigorous growth of stalks and leaves under certain conditions. Heavy applications may result in lodging and in plants that are more susceptible to diseases. Usually the soil nitrogen can be maintained by turning under organic matter, such as rice stubble, green-manure crops, weeds, and other organic materials. In soils well supplied with organic matter, the decomposition of this material under submerged conditions usually liberates sufficient nitrogen as ammonia to meet the requirements of rice plants.

Under certain conditions ammonium sulphate may be applied to advantage. Applications of from 150 to 200 pounds of ammonium sulphate to the soil at seeding time at Texas Agricultural Substation No. 4, Beaumont, have materially increased the yields of rice.

The rice soils of the prairies often are deficient in phosphorus and nitrogen, and the lack of these elements rather than lack of potash is likely to be a limiting factor in rice production. The fertilizer most commonly used contains superphosphate principally and is applied at seeding time at the rate of 150 to 200 pounds per acre. Under certain conditions, however, fertilizers containing phosphorus may actually decrease the yields of rice, as they increase weed growth.

The relative effect of the same fertilizer applied at different times has been studied. In Texas yields have been essentially the same whether fertilizers were applied at seeding time or 30 days later. In Arkansas, however, the largest increases in yields from fertilizers have been obtained from applications 6 to 8 weeks after seeding.

In each of the three Southern States nitrogenous and phosphoric fertilizers may be used to advantage under certain conditions, but environment, soil, and drainage are so varied that specific recommendations for all conditions are not advisable. Local tests should determine whether applications of nitrogen or phosphorus or both are profitable.

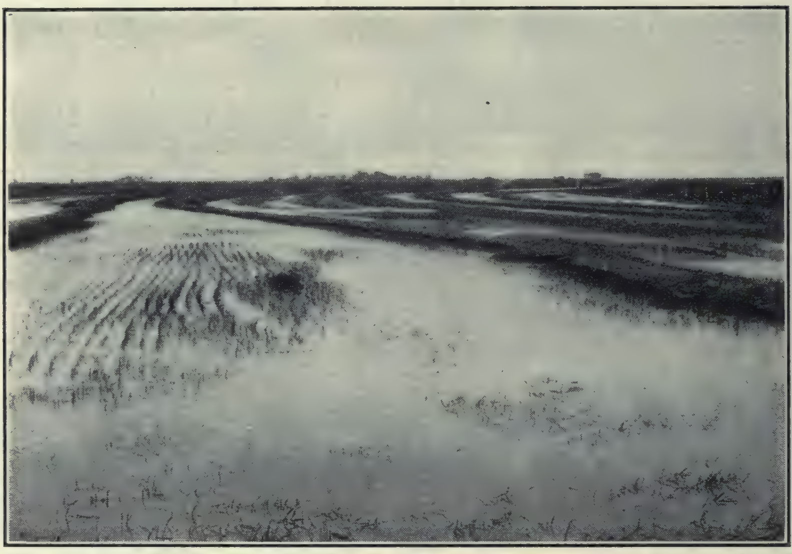

Figure 12.—A submerged field of young rice.

Probably the best way to insure high yields is to maintain an adequate supply of organic matter in the soil. The decomposition of organic matter will assist in liberating the plant-food elements already in the soil, improve the physical texture of the soil, and tend to provide for proper aeration of the roots by creating conditions favorable for the percolation of water into the soil.

IRRIGATION

Rice is grown in essentially the same way as other small grains, except that the land on which the crop is grown is submerged for 60 to 90 days or more during the growing season. Normally, when young rice plants reach a height of 6 to 8 inches the land is submerged to a depth of 1 to 2 inches (fig. 12). As the plants grow taller, the depth of water is gradually increased until it reaches 4 to

6 inches (fig. 13). During the remainder of the growing season, or until the land is drained prior to harvesting, except for special reasons, the water should be held on the land at a constant depth of about 5 inches. To maintain a constant depth of submergence, water must be applied from time to time to replace that lost by evaporation, transpiration, and seepage.

It is normally not necessary to flush the land to germinate the seed. In case it is necessary to irrigate for this purpose, however, the land should be drained promptly thereafter; otherwise the seed is likely to rot. From 24 to 48 inches of water is normally required to produce a rice crop, and of this amount from 6 to 20 inches is supplied by rainfall during the growing season.

FIGURE 13.—A field of rice 6 to 8 weeks after submerging the land.

DRAINAGE

The fact that rice is grown for several months on submerged land does not mean that good surface drainage is not essential. Good surface drainage is as necessary for successful rice culture as is a dependable supply of fresh irrigation water. Without good drainage it is difficult to prepare satisfactory seedbeds, to obtain good stands, and to produce satisfactory crops. Also the fields must be drained and dried prior to the full maturity and harvesting of the crop. Unless land is fairly well drained it is difficult to dry it sufficiently before harvest so that it will support tractors, binders, and other machinery used in harvesting operations. Harvesting costs on poorly drained land often are much higher than on well-drained land. The loss in harvesting is also greater since it is practically impossible to operate the harvesting machinery so as to save the entire crop.

Usually the land should be drained when the rice is fully headed and the heads are turned down and ripening in the upper portions. This ordinarily is about 2 weeks before the crop is mature.

HARVESTING

Rice should be harvested when the kernels in the lower portion of the heads are in the hard-dough stage. At this time the kernels in the upper portions of the heads are fully developed, ripe, and free from chalk and opaque spots, and should mill well. At this stage of development (fig. 14) the standing rice grain usually contains from 23 to 28 percent of moisture. Rice harvested before it reaches this stage of maturity is likely to have a relatively high percentage of chalky, lightweight kernels, which do not mill well. If the rice is harvested after this stage, the loss in some varieties from shattering may be increased, and owing to the probability of checking or cracking of the kernels the mill yield of unbroken rice is also likely to be reduced. Rice usually is harvested with grain binders drawn by tractors, mules, or horses (fig. 15).

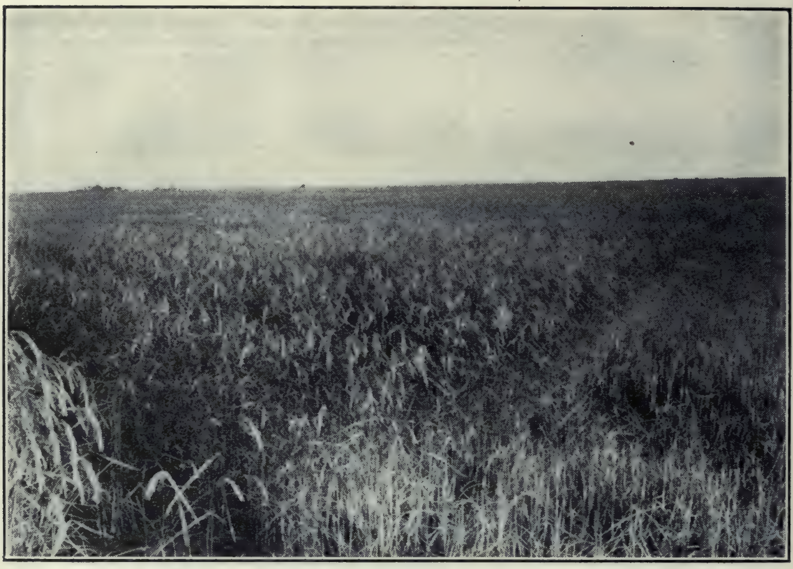
FIGURE 14.—A field of mature rice ready for harvesting.

Harvesting rice by the windrow or direct combining methods often is hampered in the South by weather hazards and by difficulty in pulling the machines across levees and low wet spots. Harvesting by these methods has thus far been only partially successful.

There is a relatively small district along the Mississippi River and Bayou Teche in Louisiana where rice is harvested with hand sickles, cured on the stubble, and tied by hand into bundles. It usually is placed in small stacks, but often is threshed immediately after being tied. A brief discussion of the practices followed in growing rice along the Mississippi River and in the Bayou Teche area is given on pages 21 to 23.

SHOCKING

Rice harvested with a binder should be shocked promptly, and in such a manner that the grain, while curing, is protected from rain and sun as much as possible. Excessive moisture interferes with

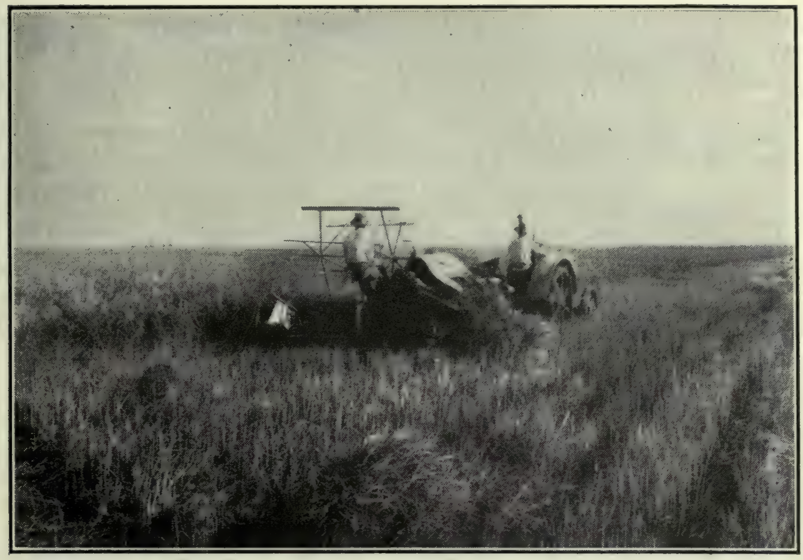

FIGURE 15.—Cutting rice with a grain binder.

proper hardening, and alternate drying and wetting may result in checking of the kernels. Careless shocking may thus result in rice of inferior milling quality and low price. The market value of rough rice depends very largely upon the percentage of head (whole) rice obtained in milling.

Rice cures well in shocks that are properly capped and provide for a free circulation of air. Usually from 9 to 12 bundles are placed in a shock, 1 or 2 of which are used as a cap. If the straw in the bundles is wet or too green, fewer bundles are placed in a shock (fig. 16).

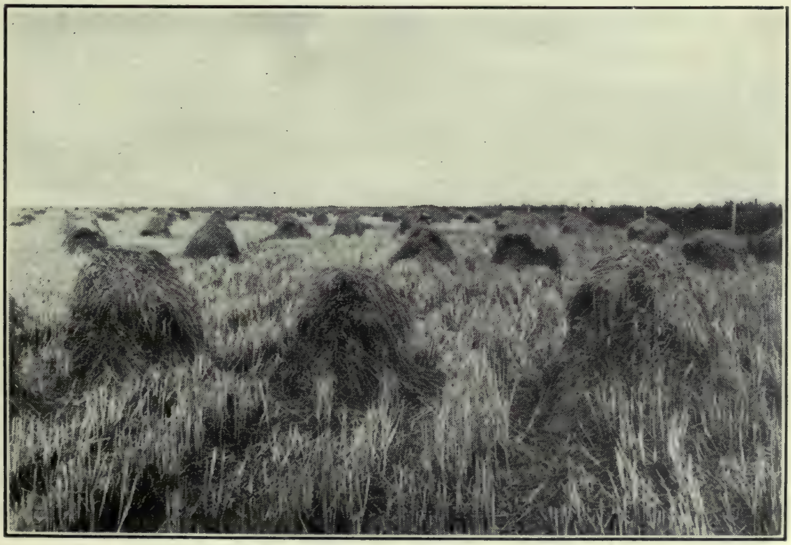

FIGURE 16.—A field of rice in the shock.

THRESHING

The rice is threshed after it has cured in the shock from 10 days to 2 weeks (fig. 17). The threshed grain is stored on the farms or in public warehouses (fig. 18) until sold to rice mills, in which it is prepared for market. The straw should be thoroughly dry and the

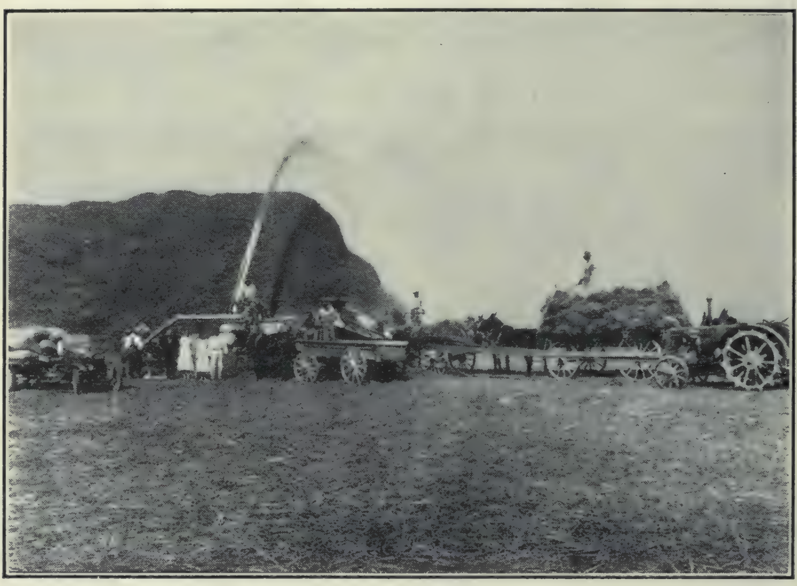

FIGURE 17.—Threshing rice.

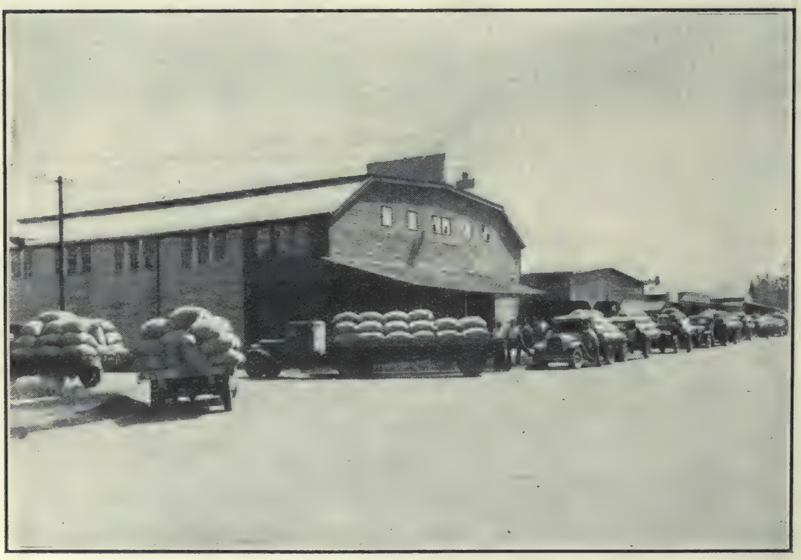

FIGURE 18.—Trucks loaded with rough rice at a warehouse.

rice hard. Even well-dried rice is difficult to thresh when exposed to dew, high humidity, or rain at the time of threshing. Often shocks are spread to dry for a few hours before threshing operations begin. In threshing damp rice there often is a loss of grain due to poor separation. It is difficult to store damp rice without its spoiling. In threshing, an effort should be made to prevent cracking of the grain, because this lowers the milling quality of the rough rice. It is self-evident that threshers should be thoroughly cleaned when changing from one farm to another and from one variety to another, in order to prevent mixtures and also to prevent the spread of noxious weed seeds.

COST OF PRODUCTION

The cost of producing a crop of rice varies from year to year, owing to fluctuations in the cost of labor, power, water, seed, interest rates on investment, depreciation, yields per acre, and other items. The cost of production often ranges from about $35 to $50 per acre.

MISSISSIPPI RIVER AND BAYOU TECHE DISTRICTS

Each year several thousand acres of rice are grown along the Mississippi River and in the Bayou Teche district of Louisiana. The methods of production used in these areas are a combination of modern and earlier practices and are briefly discussed below.

Rice probably was first brought into Louisiana by the Frenchmen led by Bienville, who founded the city of New Orleans in 1718. Rice growing gradually extended into the parishes north of New Orleans, and its cultivation by the majority of planters up to the Civil War was for domestic use. Before the Civil War Plaquemines Parish produced about two-thirds of the rice grown in the State, but after the war it soon lost its rank, owing to the rapid increase in the rice acreage on hitherto idle lands, on former sugar plantations, and on the lowlands. It is estimated that in the 5-year period 1932–36 about 12,900 acres were sown annually to rice in the Mississippi River district.

The alluvial and "buckshot" soils adjacent to the Mississippi River are well suited for rice culture. The buckshot soil is dark in color and contains considerable clay. The river soils are more porous than the prairie soils and hence require more water to produce a crop. The land along the river usually slopes gradually from the river to the swamps, but in some places the slope is more abrupt, and in growing rice the levees must be placed rather close together. Nearly all the river land on which rice is grown has previously been divided by drainage ditches into long narrow strips, which extend from the river to the swamps. In growing rice these strips of land are divided into smaller checks by levees constructed at right angles to the drainage ditches.

In this district the water used in the irrigation of rice is siphoned from the Mississippi River. When the level of the water is high, the water is siphoned automatically over the levees, but when the water is low it is pumped either directly into the siphons or into small ponds on the riverbank, from which it is siphoned over the levees.

In some years the river is so low that the cost of pumping is prohibitive, and the crop is injured from lack of moisture unless heavy showers occur.

The river rice crop is grown, largely by sugarcane planters, on land that has produced several crops of sugarcane or corn or on abandoned weed-infested plantations on which two or more consecutive crops may be grown. The land usually is plowed in the winter, and in the spring the seedbed is prepared by disking and harrowing.

The same varieties are grown in the river sections as on the prairies, but the proportion of early maturing varieties probably is larger. The rice is sown with endgate seeders at the rate of 120 to 150 pounds per acre and covered with a harrow. Seeding often begins the latter part of February. The fields, with few exceptions, are irrigated and drained after seeding, to induce prompt germination and obtain good stands. After the seedlings emerge, the method of irrigation is essentially the same as on the prairies.

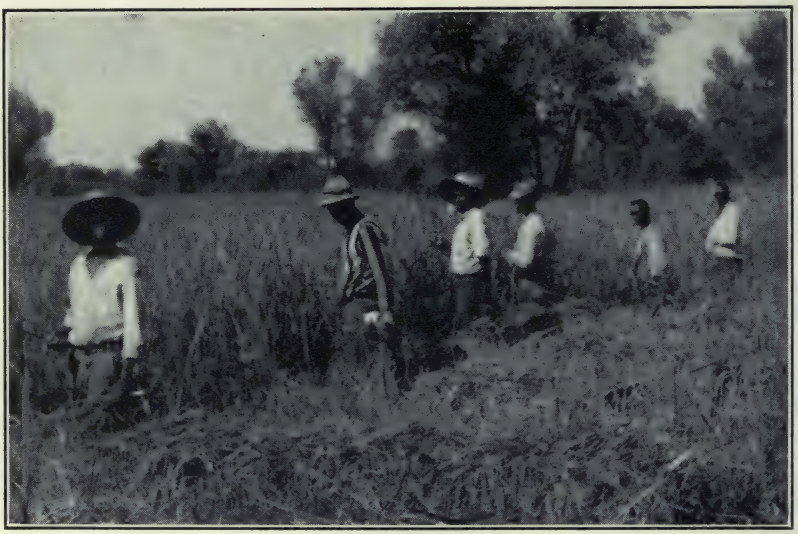

FIGURE 19.—Cutting rice by hand along the Mississippi River.

The crop is cut with hand sickles (fig. 19) and allowed to cure on the stubble for about 24 hours before it is tied into sheaves and placed in small stacks. The sheaves are taken from the stacks to the thresher, which is usually housed under a shed. Under favorable conditions, the crop is often threshed as soon as it is tied into sheaves. The threshed rice usually is shipped to the mills immediately by water or rail.

In the river district, weeds, which grow abundantly, must be destroyed either by hand-pulling or by mowing. It is sometimes necessary to handweed the fields two or three times. When the weeds are too numerous to pull by hand, the water on the fields is lowered, and the rice and weeds are mowed with a scythe at a height that does not injure the rice. After the mowing, the water is raised and the rice plants recover, but the weeds do not.

The most objectionable weeds are the tall indigo (*Sesbania macrocarpa*), Mexican weed (*Caperonia palustris*), several strictly aquatic weeds, and various grasses and sedges. Tall indigo is kept under control when the fields are in rice, but is permitted to grow in abundance when the fields are not cropped, to help maintain the fertility of the land.

The same diseases and insects occur that attack rice in other parts of the State, but straighthead is more common and causes greater losses in the river district.

That portion of the State of Louisiana traversed by the Bayou Teche is generally referred to as the "Teche," or "Evangeline Country." The soils in this district and the crops grown, with few exceptions, are much the same as in the Mississippi River district. The soil is less porous than that along the river, but not so impervious as are the prairie soils. The method of irrigation is more like that followed on the prairies than that in use in the river district.

Until comparatively recent years the rice crop probably was grown as "Providence", or upland rice. Providence rice was grown on low areas enclosed by levees on the lower side to hold the water. Local rainfall was depended upon to supply the water required to mature the crop. On the more porous soils the crop was often grown in rows and cultivated to control weeds.

It is estimated that in the 5-year period 1932–36 an annual average of 8,000 acres was sown to rice in the Teche district. The preparation of levees and seedbed, the varieties, and seeding in the Teche district are similar to those in the Mississippi River district. Seeding, however, is begun later in the spring. The fields seldom are irrigated to induce germination. The irrigation water is obtained largely by pumping from Bayou Teche. The crop is largely cut by hand but is threshed and marketed in practically the same manner as on the prairies. The same weeds, diseases, and insects affect the crop as in the other rice-growing districts of the State.

WEEDS

Rice is grown under conditions that are very favorable for the growth of aquatic (water-loving) and semiaquatic weeds. If not eradicated promptly, such weeds increase rapidly and soon practically take possession of the fields, reduce yields, and detract from the value of the threshed product.

Weeds possess unusual vigor and usually produce an abundance of seeds, which often have the ability, under certain conditions, to lie dormant in the soil for years. Weeds are difficult to control, once they become established. The best method of control, therefore, is to prevent them from becoming established in the fields.

Weed seeds are spread by irrigation, drainage, floodwaters, wind, livestock, and machinery, and sowing foul seed. The spread of weeds is encouraged by permitting them to grow and produce seed on levees and ditch banks and in uncultivated corners of the fields. Weeds can be kept under control only by constant effort in preventing their propagation and spread.

The most common and troublesome weeds in the rice fields of the South are red rice (*Oryza sativa*), "curly indigo" (*Aeschynomene virginica*), "Mexican weed" (*Caperonia palustris* and probably other species), "tall indigo" (*Sesbania macrocarpa*), barnyard grass (*Echinochloa crusgalli*, and *E. colonum*), umbrella weeds or sedges (*Cyperus strigosus* and others), "nigger wool" (*Fimbristylis autumnalis*), "alligator head" (*Diodia teres*), "pongati" (seaweed) (*Sphenoclea zeylanica*), "day flower" (turtle back) (*Commelina virginica*), and smartweed (*Polygonum acre*).

Red rice is the most serious weed pest. Red rice belongs to the same species as white rice, and varieties having red kernels are extensively grown in some countries. It differs from white rice in having a red instead of the usual brown kernel coat. Red rice probably is as nutritious as white rice, but in most markets highly polished white rice is preferred by consumers. The chief objection to red rice is the fact that in milling rough rice containing some red grains, which often are smaller than those of the white, it is frequently necessary to mill so closely, in order to remove the red kernel coats, that considerable white rice is broken. The milled product has an unattractive appearance unless the red kernel coat is removed. The presence of red-streaked kernels in milled rice lowers its market value.

Red rice is spread largely, if not entirely, by using seed that contains red grains. Seed of the red rice variety, which is most troublesome in the Southern States, shatters readily, and the seed, like that of other weeds, has the ability to retain its viability for several years when buried in the soil. Unless eradicated promptly it soon practically takes possession of fields.

The common southern red rice variety can easily be distinguished from commercial rice by its sparse open drooping head (panicle), which has few grains on the branches. In growth it is more spreading than are the commercial varieties. Scattered plants in commercial fields can be pulled, but this is not practicable when red rice plants are numerous. The most effective control measure is to avoid seed containing red rice and thus prevent its introduction on clean land.

There is some natural crossing in rice, and because all the plants of the first hybrid generation and three-fourths of the second generation have the red kernel coat the proportion of red rice rapidly increases when crossing between red and white varieties occurs. The short-, medium-, and long-grain red-rice seeds and kernels, which are at times observed in rough and brown rice and in fields, probably originated as a result of natural crossing between the cultivated varieties of these types and red rice. Some of the red rice types that appear as a result of natural crossing are seemingly identical in all respects with the cultivated varieties except for the red kernel color. It is not possible to locate and pull these plants in fields.

Hand pulling, mowing, summer cultivation, and pasturing are the best means of controlling not only red rice but also curly indigo, tall indigo, Mexican weed, alligator head, barnyard grasses, umbrella weeds, and nigger wool when they are present in rice fields. Every precaution, however, should be taken to avoid introducing these and other weeds to clean land in the rice seed. The expense of hand-pulling weeds is prohibitive if they are fairly numerous.

DISEASES

There are several diseases that attack the rice plant in the Southern tates, but only a few are of economic importance. Seedling blight, aused by the fungus *Sclerotium rolfsii* Sacc., attacks germinating eeds and young seedlings in warm moist weather before the root ystem is sufficiently developed to resist invasion. It is very destrucive to germinating seeds and young seedlings that have emerged. he fungus destroys the tissues of the roots, and the seedlings fail to merge or die after emerging. Early sown rice seems to be more subect to injury by this fungus than that sown late. This probably is ue to the fact that conditions are more favorable for rapid germinaion and vigorous seedling growth late in the season; hence the rice eedlings are less subject to attack by the fungus.

Stem rot is caused by the fungus *Leptosphaeria salvinii* Catt. This ungus attacks the leaf sheaths of the plants, at the water line, when rowing on submerged land. The small black spot on the leaf sheath nlarges, and eventually the tissues of the sheath and stem are largely estroyed and the affected plants may lodge. If the disease develops arly it may prevent the plants from setting seed. In cases of severe nfection, yields are materially reduced by failure of the plants to set eed or by lodging of the plants that have set seed. There is further oss due to difficulty in harvesting a crop that is lodged and the poor uality of the rice produced by lodged plants. The development of he disease and losses due to it may be checked by draining the water rom fields about 6 weeks prior to maturity and then keeping the nd wet but not submerged.

Leaf spot, due largely to infection by the fungi *Helminthosporium ryzae* V. B. de Haan, and *Cercospora oryzae* Miyake, causes a reducion in yields and in the quality of the rice produced. When plants re severely affected, the healthy leaf area is so materially reduced efore the plants mature seed that the grain often is irregular in hape, light in weight, chalky, and of poor milling quality. Varieties iffer in susceptibility to the leaf spot diseases, and the best control easure appears to be the use of resistant varieties.

Straighthead is a physiological disease and is not caused by any ungus or bacterial organism. As the name indicates, heads of afected plants remain erect and fail to set seed. Badly diseased plants ay even fail to head. Plants affected with straighthead have leaves hat are darker green and stiffer than normal, and they remain green fter the normal plants have matured. The roots of affected plants re usually large and often fail to produce small branch roots and oot hairs. The disease apparently is caused by organic materials hat, in certain stages of decay, interfere with normal root developent. The disease often can be controlled by draining the land bout 4 to 6 weeks after it has been submerged and allowing it to ry out thoroughly before resubmerging.

The white tip disease apparently is associated with a shortage of ron in the plant. Plants affected have chlorotic white leaf areas and ips, twisted boots, stems, heads, and deformed seeds. In severely ffected plants the heads often fail to emerge fully from the leaf heaths. Yields often are reduced, and the quality of the rice produced is inferior to that of normal plants. Available informatio indicates that acidification of certain soils and the addition of organi matter to others have proved to be beneficial.

INSECTS[2]

The rice crop is relatively free from severe damage by insects, bu each year they injure the yield and grain quality somewhat. Th principal injurious insects are the rice stinkbug (*Solubea pugna* (F.)), the rice water weevil (*Lissorhoptrus simplex* (Say)), sten borers, and the sugarcane beetle (*Euetheola rugiceps* (Lec.)).

By means of its long beak, the straw-colored, shield-shaped stinkbug sucks the milky juice from the rice kernel during its early development. The bugs may consume the entire contents of the kerne when in the milk stage, so that grain is not produced. When kernel in the dough stage are attacked, portions of the contents are extracted, leaving a chalky discolored area. Kernels so affected ar called pecky rice. Molds often enter the punctures and cause blac specks on the kernel, and these kernels often are broken in milling Each year stinkbugs cause some reduction in yield and often affec adversely the quality of some of the rice produced in Arkansa Louisiana, and Texas. Late-maturing varieties appear to be mos severely attacked, as late in the season the bugs often are present i large numbers.

The rice water weevil in the larval stage is known as the rice roo maggot. The maggots feed on the roots at the base of the rice plant The roots may be pruned off, and in some cases even killed, and th development of the plants retarded. The extent of the injury to th crop as a result of root pruning appears to depend upon severa factors. Information contained in Louisiana Agricultural Experiment Station Bulletin 214, Damage by Rice Water Weevil Prove Negligible, indicates that in Louisiana the injury to the crop is ver slight, whereas in Arkansas the injury is apparently rather extensive and according to Arkansas Agricultural Experiment Station Bulletin 299, the Rice Water Weevil, yields may be reduced as much as 3 percent.

Stems of rice plants are attacked by the larvae of the sugarcan moth borer (*Diatraea saccharalis* (F.)) and the rice stalk bore (*Chilo plejadellus* (Zincken)). The larvae (worms) bore into th stem and feed on the inner surface. This weakens the stalk, an often the head turns white, fails to bloom, and sets no seed after i emerges. The losses caused by borers are difficult to measure, bu have been estimated at one bag of rice per acre. Varieties havin large stems appear to be more susceptible to injury than those havin small stems.

Although the sugarcane beetle is known in Louisiana principall as a pest of sugarcane, it is found injuring rice both before and afte irrigation. This black, robust beetle gnaws the stem between th ground surface and the roots of the plant, usually causing it to withe and die. Many plants in a row are sometimes killed in this way Rice plants growing on the levees may be injured throughout th season by this beetle.

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[2] See Farmers' Bulletin 1543, Insects Injurious to the Rice Crop.

RICE MILLING

The kernel of rice as it leaves the thresher is enclosed by the hull or husk and is known as rough rice. A sack of rough rice weighs 180 to 225 pounds, a barrel of rough rice 162 pounds, and a bushel of rough rice 45 pounds. A crop of rice harvested with a binder yields about equal weights of rough rice and straw. The rough rice when milled yields about 63.9 percent of whole and broken kernels, 12.9 percent of bran, 3.7 percent of polish, and 19.5 percent of hulls. Rough rice is used for seed and also as feed for livestock, but most of it is sold to millers, who prepare it for market (fig. 20).

FIGURE 20.—A rice mill in which the rough rice is prepared for market.

In milling, the rough rice is first screened and fanned to remove trash, chaff, weed seeds, dried mud lumps, and light seeds. It then is conveyed to the hulling stones, which remove the hulls. From the hulling stones the mixture of hulled rice, rough rice, and hulls is fanned and passed to paddy machines, in which the rough rice is separated from the hulled kernels. The rough rice from the paddy machines is returned to the stones for removal of the hulls.

The hulled kernels, known as brown rice, are conveyed to hullers, in which a part of the bran layer on the outside of the kernels and most of the germ is removed by friction. It is then passed through a second set of hullers and in some mills to a pearling cone also. From the second hullers and from the pearling cone the rice is returned to the bran reel, for separation of the bran and rice. The rice is then conveyed to the brush, in which the kernels are polished.

In the polishing process more of the bran and some starch cells are rubbed off and are separated from the rice by means of screens. The light-brown powder forced through the screens is known as rice polish. After being polished, the rice is screened and conveyed to a revolving cylinder (trumble), where it is steamed, and if it is to be coated with glucose and talc these materials are applied. The cleaned or milled rice is then separated into grades, weighed, and bagged.

UTILIZATION

The unbroken milled kernels are known as whole or head rice. This product commands the highest price and is sold under several grades established by the United States Department of Agriculture or under private classifications, which are based largely upon luster color, and size of the kernels. Milled rice is largely used boiled, as a vegetable. However, it also is used as a breakfast food in the form of a cooked cereal, puffed rice, and rice flakes: and some rice flour is used.

The broken kernels are sold as "second heads," screenings, and brewers rice and are used as food, feed for livestock, in making fermented beverages, and as a source of starch and flour. Rice starch is used in cosmetics, in laundries, in confections, in the sizing and finishing of textiles, and can be used in making pastes, glues adhesives, vinegar, acetone, and alcohol.

The bran consists of the kernel coats and the germ with varying quantities of hulls. Bran free from hulls is the most nutritious and palatable of the rice feeds. However, bran often becomes rancid if kept too long. The polish contains less fat and protein, but more starch than the bran. Bran and polish are used as concentrated feeds for livestock. Polish may also be used as food in the form of a thickening in gravies, in sauces, in puddings, as stuffing material in sausage, and in the manufacture of buttons, soap, and oil.

The hulls may be used for fuel, packing material, bedding for poultry, insulating material, soil mulch and fertilizer, and as a filler for horse collars. Hull ash is used as a bleaching agent, also as a filler for concrete and bricks, in making soaps and polishing and cleaning agents, and as a source of sodium silicate. Paper pulp and cellulose may be obtained from the hulls. The following products may be made from the cellulose: Cardboard, rayon, celluloid, and other plastics. Cellulose treated with sulphuric acid yields dextrin and glucose, which on fermentation produces ethyl alcohol. Cellulose treated with acetic acid forms cellulose acetate, from which artificial silk, films, nonshatterable glass, plastics, and rubber substitutes may be derived.

Rice straw is used for feed, and when the crop is cut and threshed by hand and the straw retains its original shape, as it often does in the Orient, it is used in making mats, sacks, sandals, brooms, hats coats, rope, and is used as bedding for livestock, for thatching roofs for making hedges to protect young plants, for fuel, and as a soil mulch and fertilizer. Rice straw may also be used in the manufacture of paper and cardboard and as a source of cellulose from which as has already been indicated, many products may be derived.

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Soil Defense in the South

FARMERS' BULLETIN No. 1809
S. DEPARTMENT OF AGRICULTURE

FOREWORD

This bulletin describes farming practices that conserve soil, and how such practices may be applied to farms in a large part of the South. Its scope is limited to that part of the Cotton Belt extending west from the Georgia–Alabama line to central Texas and southern Oklahoma. Its subject matter is based largely on the soil conservation practices employed by farmers who live within the various project areas of the Soil Conservation Service in this section of the cotton country. Erosion control practices for cotton farms to the east are described in Farmers' Bulletin 1767, Soil Defense in the Piedmont.

Washington, D. C. Issued September 1938

Soil Defense in the South

* * *

By E. M. ROWALT
Soil Conservation Service
in collaboration with specialists in soil conservation

UNITED STATES DEPARTMENT OF AGRICULTURE

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FARMERS' BULLETIN No. 1809

UNITED STATES GOVERNMENT PRINTING OFFICE
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FIGURE 1.—*Year after year in the South, row crops are grown on three-fourths of the cropland. Intertilled crops such as cotton and corn afford little or no protection to the soil at any time during their growing period.*

Cotton, Corn, Trees, and Grass

Year after year in the South, cotton, corn, and other row crops are grown on fully three-fourths of the cropland (fig. 1). Owing to this persistent and continuous growing of intertilled crops on lands that, because of the character of soil, slope, and climate, are particularly subject to erosion, soil deterioration from this cause is farther advanced and has destroyed more land in the Cotton Belt than elsewhere in the United States.

If a list were made of field crops that permit Cotton Belt soils to wash most readily, cotton and corn would stand at the top. Neither crop affords much protection to the soil during its period of growth. After harvest, cottonland and cornland enter the winter bare, except for the weeds and grass which appear after the crops are laid by. Winter cover crops follow cotton and corn on only a small proportion of the uplands in the South.

Close-growing, fibrous-rooted plants, on the other hand, hold the soil in place. If a list were made of the crops that hold soil, at its head would stand grass and trees. Grass plants and trees send out hundreds of fine, fibrous roots which lie just under the ground level (fig. 2.)

Dig your fingers into a forest soil or through a thick sod and feel the interlacing roots. These roots help to bind the soil. On sod land and on a forest floor there is a thin layer of vegetable material that performs an important service in helping to prevent soil from washing. It absorbs water, hinders its flow, and removes suspended particles of soil. Clear water soaks into the ground more readily. It will not, as muddy water does, choke the soil pores and retard penetration, which permits run-off to gain volume and speed, and multiply its soil-carrying power. Consider also the dense growth of stems and leaves which protects sod-covered and forested land, breaking the force of falling raindrops.

Before cultivation, the productive surface layer of soil seldom in the Cotton Belt exceeded a depth of 12 or 15 inches on the blackland prairies and smoother parts of forested land or more than 6 or 7 inches on the steeper forested slopes. In the short span of years since cultivation began—usually less than 50 years ago and seldom longer than a century in most of the South—much, and often all, of the topsoil has been removed from large areas. The nature of the process which removes such vast quantities of soil from cultivated fields is, strangely, not widely understood. We have grown accustomed to the gully and accept it as the symbol of erosion; but sheet erosion, the process which precedes gullying, goes on almost unnoticed. Rain water flowing from a clean-tilled field is always muddy, never clear. Laden with soil material, it is the color of the land over which it has flowed. Thus each rain of sufficient intensity to cause run-off, strips a thin layer of surface soil from the land. This process, repeated again and again, is called sheet erosion.

Nature required many hundreds of years to build a thin mantle of topsoil, for soil can become deeper only when less is lost from the surface than is formed from the parent material beneath. Some estimates set the rate of soil formation at 400 to 1,000 years for a single inch. With these estimates in mind let us look at the rates soil is removed under various types of vegetative cover and conditions as revealed in tests at a number of soil and water conservation experiment stations.

At Tyler, Tex., a plot continuously in cotton lost 105 times as much soil as a plot in grass and 237 times as much soil as a plot in forest, in 4 years of an experiment. Differences even more favorable to grass and forest were obtained at the experiment station at Guthrie, Okla. These results are shown in table 1.

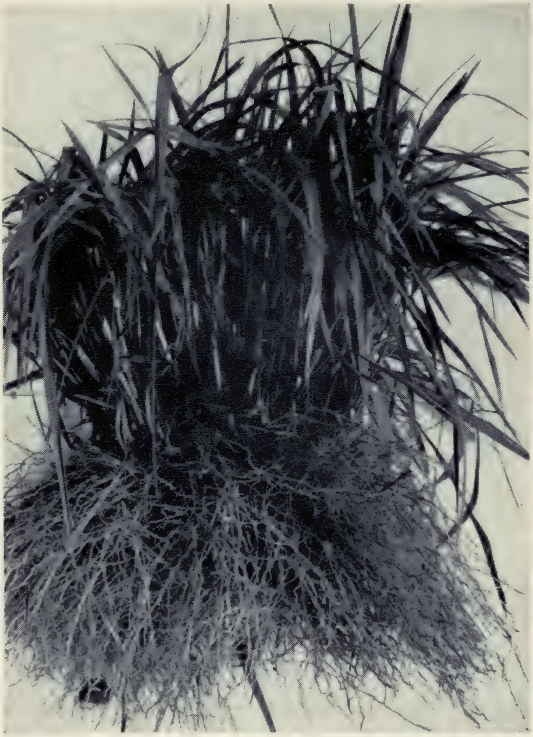
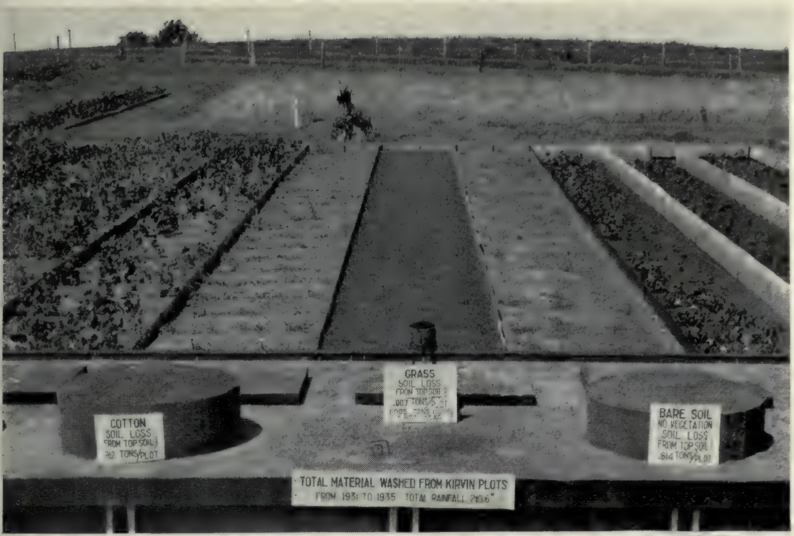


Figure 2.—*Grass plants send out hundreds of fine, fibrous roots which lie just under ground level. These roots help to prevent soil from washing.*

The Southern Forest Experiment Station, at Holly Springs, Miss., reports that under oak-forest conditions 40,000 years would be required to remove 6 inches of topsoil from a 10-percent slope, at the rate soil was carried away by run-off in a 2-year study period. The figure for a Bermuda grass plot was 10,000 years. Contrast these figures with 28 years, the length of time that would be required to remove 6 inches of soil from a cotton plot planted on the contour, and 10 years for the cotton plot planted in sloping rows, as reported by this station.

Tests of this kind are usually made on small plots owing to the difficulty of catching and handling run-off from field areas. The plots are surrounded by steel guards to prevent intake of water except from overhead (fig. 3). All of the silt and run-off are caught in concrete tanks and measured.


GRASS
SOIL LOSS
FROM TOP SOIL
COTTON
SOIL LOSS
FROM TOP SOIL
TONS/PLOT
BARE SOIL
NO VEGETATION
SOIL LOSS
FROM TOP SOIL
.814 TONS/PLOT
TOTAL MATERIAL WASHED FROM KIRVIN PLOTS
FROM 1931 TO 1935 TOTAL RAINFALL

IGURE 3.—*Tests of rates of erosion under various kinds of cover and conditions are made in plots surrounded by steel guards to prevent intake of water except from overhead. The volume of the silt and run-off caught in the concrete tanks is measured.*

The rate at which soil is lost from these experimental plots is revealing. It xplains, in tons of soil, in inches of surface soil, why land depreciates so quickly nder cotton. It explains the trail of discarded farm land (fig. 4) which followed he advance of cotton across the South—a trail extending from the Carolinas, ound the southern tip of the Appalachians, and reaching west through Ala-ama, Mississippi, Louisiana, part of Tennessee and Arkansas, into Texas and Oklahoma. Millions of acres of land in these States are no longer fit for profitable ultivation. Millions of acres have been turned back to nature. It is said that n experienced traveler can guess the number of years that have elapsed since otton last was grown by estimating the age of the pine trees with which nature n many places reclaims discarded cottonfields.

ABLE 1.—Average annual soil and water losses from control plots under various kinds of cover at the Tyler, Tex., and Guthrie, Okla., soil conservation experiment stations

Place	Crop	Slope	Rainfall lost as run-off	Soil losses an acre	Years
		Percent	*Percent*	*Tons*	
Tyler	Continuous cotton	8.75	19.5	19.08	1931–34
	Bermuda sod	8.75	1.35	.18	1931–34
	Forest	12.5	.6	.08	1932–35
Guthrie	Continuous cotton	7.7	14.22	24.29	1930–35
	Bermuda sod	7.7	1.23	.032	1930–35
	Virgin forest	5.2	.20	.017	1931–35

In the whole broad stretch of land known as the Cotton Belt there is litt cultivated land, even where the slopes are gentle, that is not marred by erosio surveys reveal. In upland cotton country, where damage is written across t face of the earth in a scrawl of gullies, advanced erosion has impoverished ma farm families (fig. 5) and has caused trade to languish in many towns; and t debris of erosion has clogged stream channels, damaging bottom lands and cro and has filled reservoirs, causing losses in hydroelectric power and municip water supply.

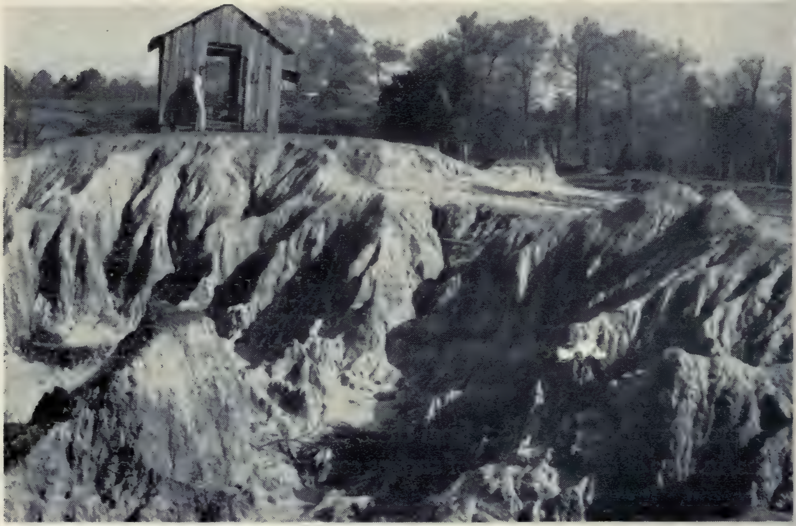


FIGURE 4.—*Across the South there is a trail of discarded cottonland made poor soil erosion. Gullies have ruined much of it.*

Grass to Cotton to Weeds

In the southern part of the blacklands of Texas there is an old abandon community. It will not be singled out here by name, for there are many othe like it in the South equally deserving of mention. An old resident told m recalling the years after 1880:

> I guess this was once the best farming section in the whole country. Crops were mighty go three-quarters of a bale an acre. There was a general store here then, and it did a thriving busine Forty thousand dollars passed over the counter in a year. Had six full-time clerks on the jo Goods were brought from Austin by wagon freight. There was a doctor here, and a druggi About 2,500 bales of cotton were ginned annually at the big gin. It's all deserted now, you see.

The year 1900 was a big cotton year, the old man recalled. Land values soar that year, but from then on the story of the town is a story of defeat. The lar couldn't stand continuous row cropping. It washed badly. Yields on t steeper slopes, broken last at the height of the period of prosperity, first began ecline; but by 1907 the decline was general. Business fell off. In 1913 torrential ains washed away tons of the remaining topsoil from the fields, cutting gaping ullies. That year land loans went unpaid. By 1919 much of the land was bandoned. The farm families had given up and moved away. Crop failures in 925 and 1926 ended the life of the trading center. The stores closed, and the erchants moved away. In one store the goods still rest on shelves, dust-covered eminders of a better day. The folks nearby now call it the Ghost Town. It is ke an abandoned mining town—the soil mine played out. Some of the land is razed. Most of it, however, lies there unused, covered with Johnson grass and eeds, the property of loan companies and absentees.

Influence of Climate on Soil Losses

Soils in some European localities unquestionably wear better than ours. The nglish, notably, have farmed for centuries without serious losses of topsoil, for he climate and the cropping systems there are more favorable to a lasting soil. n England rains are usually gentle. It rains oftener, about 200 days a year, but ith less violence and intensity. The average annual rainfall is about 26 inches, ardly more than half that of many of our Southern States, where sharp, steady ownpours beat against a bare soil during storm periods. Storm periods usually ccur in the South in the fall and winter, when the land is poorly protected, and the spring, when seedbeds have been freshly prepared and the soil is susceptible to severe washing.

IGURE 5.—*Erosion impoverishes families and leads to abandoned fields, abandoned farms, and languishing trade.*

Climate, however, does not account wholly for the slower erosion rates i these old European farming countries. Much of it is due to the difference in th crops grown. European farmers raise more close-growing crops than America farmers grow, more grass and small grains; and they pay better attention to th farm woods. There is in this country roughly 360 million acres of cropland. I 1937 about 100 million acres was in corn, 35 million in cotton, and 20 millio acres in potatoes, sorghums, tobacco, and other crops that leave the soil expose to the rain during the growing season. Europe outside of the Union of Sovie Socialist Republics had almost the same number of acres of cropland as the Unite States, but only 65 million acres was in row crops, as compared with our 15 million. We, in the United States, expose two and a half times as many acres t the forces of erosion and farm no more land.

Influence of Slope on Soil Losses

The length and the degree of slope directly influence the quantity of soil was from cultivated fields. Generally speaking, longer slopes lose more soil tha shorter slopes, and steeper slopes more soil than moderate slopes, during an given erosive period. Measurements have been made of the influence of thes factors at the 15 soil and water conservation experiment stations in the countr The results at Tyler, Tex., on cotton land (which are very similar to the result obtained at the Guthrie, Okla., station) and at Clarinda, Iowa, on cornlan illustrate sufficiently the importance one must give to the slope influence i devising an erosion-control program.

At Tyler a plot 36.3 feet long on an 8¾-percent slope, planted to cotton, los soil at the rate of 13 tons an acre a year. A plot 72.6 feet long, twice the lengt of the first plot, lost soil at the rate of 19 tons an acre. A plot 145.2 feet long los soil at the rate of 36 tons an acre a year. At Clarinda, Iowa, on still longe slopes, a corn plot 157½ feet long, on an 8-percent grade, lost soil at the rate 40 tons an acre. A slope twice as long lost soil at the rate of 53 tons. From plot 630 feet long 67 tons of soil an acre were lost.

To measure the influence of degree of slope is experimentally more difficul Soil conditions change in places with sharp fluctuations in slope. At Tyle however, there are two plots on Kirvin soil, one on an 8¾-percent slope and th other on a 16½-percent slope, which are comparable. In continuous cotton, th steeper slope lost 57 tons of soil a year; the more moderate slope 24 tons a year.

Defense Measures

In times past when there was plenty of new land it was customary for the Cotton Belt farmer to grow row crops until his land became badly washed and gullied and unfit for further cultivation. Then he moved west and cleared a new farm. The western agricultural lands are now all taken up. All of the good farming land had been claimed long before the public domain was officially closed to homesteading a few years ago. Although the covered-wagon days are past, many of the careless farming habits bred in those days of land plenty remain with us.

However, it is now generally realized that the problems created by soil erosion can no longer be solved, as in earlier days, by moving to new lands. Nor can they be solved by putting all of the land back to trees and grass. We shall continue to need large acreages for growing food and fiber. We can, however, use our land in such a way, apply to each field such proper safeguards, that the productive life of our land will be prolonged, perhaps indefinitely.

Many measures and practices have been suggested for arresting soil erosion. Given trial, certain measures have succeeded partially and earned general acceptance in certain parts of the country. Some have grown popular in one section, others in another. Terracing and contour cultivation, for example, have long been the main reliances of southern farmers. Northern farmers have depended more upon systems of crop rotation to preserve soil productivity, although in a few widely scattered communities they have employed the practice of strip cropping to check soil washing. But few farmers, North or South, have been able to devise a scheme of land use that provided for adequate control of erosion on all of the sloping land in their farms.

Recognizing this, the Congress created the Soil Conservation Service and specifically charged it to bring together information on all known soil conservation measures and to demonstrate these practices where they might be viewed and studied by farmers. To accomplish this, a number of project areas of from 25,000 to 150,000 acres each were selected in the various erosion-problem areas in the United States. The labor of a part of the Civilian Conservation Corps was assigned to the Service to help do the job. The locations of soil conservation projects and camps where soil conservation work is underway in seven cotton States are shown in figure 6.

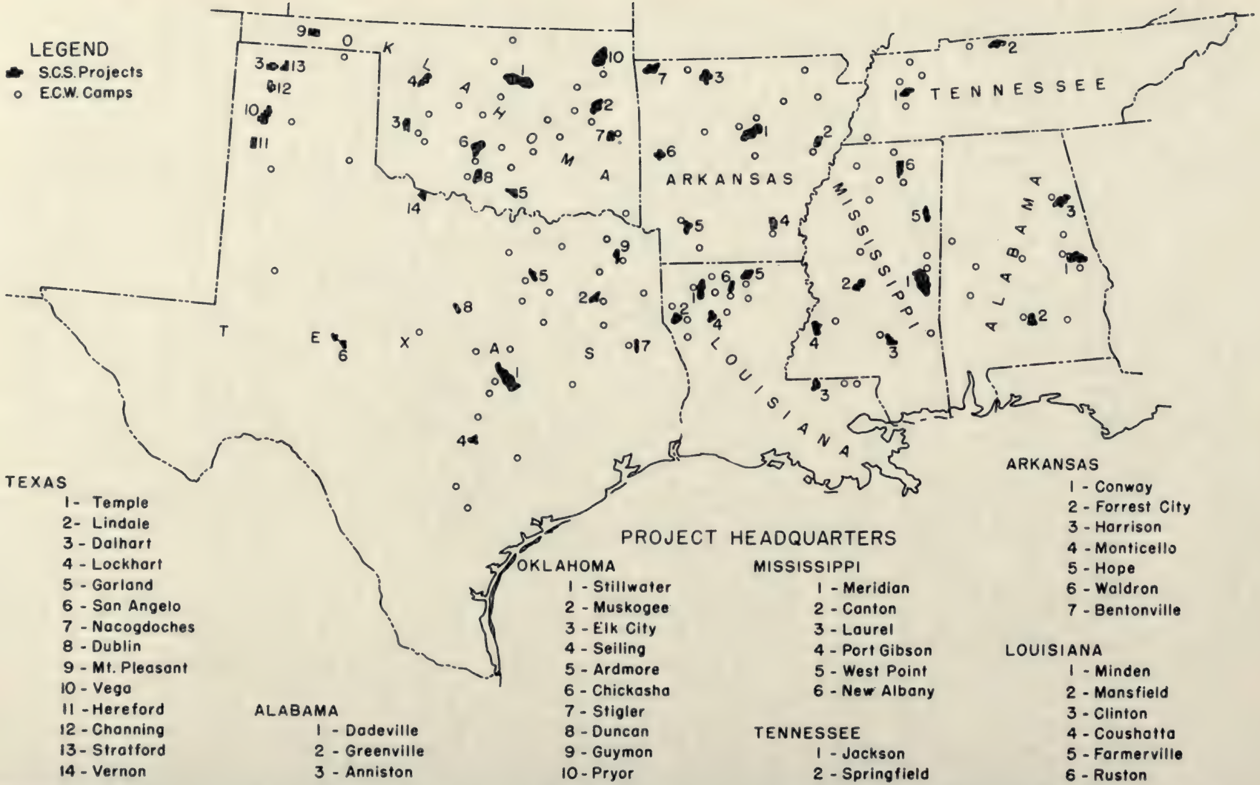

LEGEND
S.C.S. Projects
E.C.W. Camps
OKLAHOMA
TEXAS
ARKANSAS
LOUISIANA
MISSISSIPPI
ALABAMA
TENNESSEE
PROJECT HEADQUARTERS
TEXAS
1 - Temple
2 - Lindale
3 - Dalhart
4 - Lockhart
5 - Garland
6 - San Angelo
7 - Nacogdoches
8 - Dublin
9 - Mt. Pleasant
10 - Vega
11 - Hereford
12 - Channing
13 - Stratford
14 - Vernon
ALABAMA
1 - Dadeville
2 - Greenville
3 - Anniston
OKLAHOMA
1 - Stillwater
2 - Muskogee
3 - Elk City
4 - Seiling
5 - Ardmore
6 - Chickasha
7 - Stigler
8 - Duncan
9 - Guymon
10 - Pryor
MISSISSIPPI
1 - Meridian
2 - Canton
3 - Laurel
4 - Port Gibson
5 - West Point
6 - New Albany
TENNESSEE
1 - Jackson
2 - Springfield
ARKANSAS
1 - Conway
2 - Forrest City
3 - Harrison
4 - Monticello
5 - Hope
6 - Waldron
7 - Bentonville
LOUISIANA
1 - Minden
2 - Mansfield
3 - Clinton
4 - Coushatta
5 - Farmerville
6 - Ruston

FIGURE 6.—*Locations of project and camp areas where farmers are cooperating with the Soil Conservation Service in effecting a complete, coordinated erosion-control program in seven cotton-producing States.*

In these project and camp areas, farmers sign cooperative agreements with the Soil Conservation Service. These agreements outline the farming practices to be followed. The soil conservation measures agreed to for each piece of land are determined by the farmer and representative of the Service. They go over the farm field by field (including the farm woods) and decide how best to meet the erosion problem on each parcel of land. Together they work out a plan for each field, basing their decisions on crop needs for the farm, surveys previously made as to slope, soil type, and degree of erosion, and personal experience with each field. They depend not upon a single measure or practice to control erosion but upon a combination of measures and practices. On land least susceptible to soil washing, for example, they depend upon contour cultivation and crop rotation to do the job. Land more susceptible to erosion also is strip-cropped or terraced, or strip-cropped and terraced. Land still more susceptible to washing is kept under continuous cover such as meadow crops, pasture grasses, and forest trees provide.

The changes that occur in the organization of a farm as a result of this effort to arrest erosion are discussed and illustrated in the section, The Complete Farm Program. To make that section fully understood, however, it is necessary first to describe individually the various soil conservation measures employed in the Cotton Belt on farms under agreement.

Terracing

In the Cotton Belt the terrace is the most widely used defense against soil washing. The practice of terracing is generally well established there. It followed close on the heels of advanced erosion, coming into use in each agricultural section, however, only after much soil had been lost and erosion had become an obvious menace to cultivation. Unfortunately, terracing too often has been accepted as a cure-all erosion-control practice, whereas experience plainly indicates it is not. In the South, where the cropping system is especially lacking in erosion checks and the climate is conducive to severe washing, soil erosion is too complex a problem to be solved by the application of a single defense measure. The presence of terraces in abandoned fields—sometimes well-made terraces—shows clearly that if cotton farming is to continue on sloping land, other protections in addition to terraces must be provided.

A great deal of progress has been made in terrace design in recent years. When terraces first came into use they were small and weak, of excessive grade along the channel, and seldom satisfactory. In the past, terraces were built in some fields which, owing to the degree of slope, the type of soil, or to an advanced stage of erosion, should not have been terraced. Many of these terraces broke during storms. When a break occurred in an upper terrace, terraces lying lower on the slope usually gave way before the force of the water released from behind the embankments above, and the land gullied. But as the need for size and strength became obvious, implements for building better terraces (fig. 7) were devised, an terraces now are generally much larger and stronger. The broad-base te races now recommended fail much less frequently than the narrow-ridge terrac used to.

The modern terrace is broad, high, and strong, and of ample channel capacit to withstand the heaviest storms if properly constructed and maintained ar properly supported by other erosion-control measures. It consists of an er bankment of earth 18 to 24 feet broad and 18 to 22 inches high. On the upp side of the embankment there is a definite drainage channel in which water carried slowly away to a protected outlet.

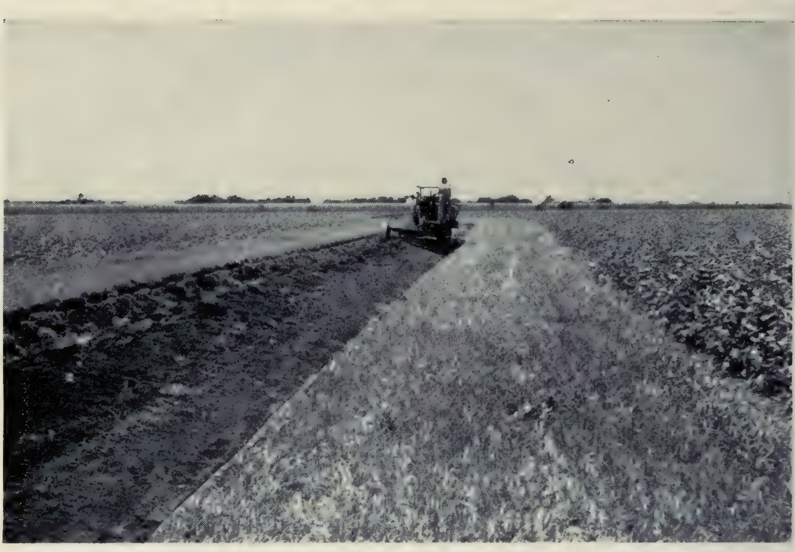


FIGURE 7.—*Early terraces were small and weak and frequently failed. As the ne for size and strength became obvious, implements were devised for building large stronger terraces at lower cost.*

There are two general types of broad-base terraces. One type, primarily a absorption structure, is used principally in fields in which the soil readily absor water, in areas deficient in rainfall, where moisture must be conserved to produ a crop successfully. It is made level throughout its length, and its ends are pa tially closed. The second type is the graded broad-base terrace, the kind use commonly in all of the Cotton Belt except in dry-farming areas. The purpose the graded terrace is, primarily, to check the rate of soil loss by providing order surface drainage. Its function of promoting absorption of water into the so though important, is secondary. For erosion control, the so-called modifie Mangum and Nichols terraces are used. The differences between the two a chiefly in manner of construction and in the depth of the terrace channel. building the modified Mangum terrace, part of the soil is moved uphill and pa downhill. In building the Nichols terrace all of the soil is turned downhill. The drainage channel of the Nichols terrace consequently is more ditchlike than that of the modified Mangum; and is frequently cut out of the subsoil. It is claimed for the Nichols terrace that it is easier to cross with machinery, that fewer breaks occur on impervious soils, and that on steeper slopes it costs less to build. The modified Mangum terrace, because it is a better absorptive structure than the Nichols terrace, is preferred for deeper soils and sandy soils.

The laying-out of a terrace system requires considerable skill and experience. The use of surveyor's instruments is required for running terrace lines. Survey work must be accurate to allow for the proper terrace grade. The soil Conservation Service recommends, for most of the South, a variable-grade terrace; that is, a terrace in which the grade becomes progressively greater as the terrace approaches its outlet. Engineers in lining out a terrace usually run the first 400 feet level. They allow 1 inch of fall in 100 feet for the second 400 feet and 2 inches of fall in 100 feet for the next 400 feet. As a rule 3 inches of fall is the maximum. Terraces in project areas seldom exceed 2,000 feet in length.

Some of the terraces constructed in project and camp areas in Oklahoma are level throughout their length and open at one or both ends. Level terraces of this type are used in the western part of the State generally, and in the eastern part only on soils which take up water readily. Where the subsoil does not quickly absorb water and the terrace is more than 80 rods long a variable-grade terrace is used with a maximum grade of 2 inches in 100 feet. Where suitable, level terraces are preferred to variable-grade terraces because they store more water, and moisture is generally a limiting factor in crop production through the cotton-producing section of western Oklahoma. Rains in Oklahoma are often so intense, however, that open ends are necessary to permit excess water to escape when necessary without overtopping the terraces.

It has been previously mentioned that under similar conditions of tillage and cover long slopes wash more than short slopes of equal grade. In effect, terracing a field transforms a long slope into a series of short slopes.

For best results, terraces should be spaced so as to intercept the water before it attains erosive speed. This means that as the slope becomes steeper the terraces must be spaced closer. Otherwise erosion may be unduly damaging between terraces. There is no hard-and-fast rule of thumb for spacing terraces. There are, however, two general guides used in the South. On Soil Conservation Service project areas in Texas, terraces are spaced according to a formula worked out by M. R. Bentley, extension agricultural engineer for the Texas Agricultural and Mechanical College. This formula yields spacings as shown in table 2. Elsewhere in the South the spacings in general use are those based on the original investigations by C. E. Ramser, of the United States Department of Agriculture. These recommendations are shown in table 3. In actual field work, spacings are frequently varied slightly in order to reach a desirable outlet or to avoid obstacles.

TABLE 2.—*Spacings recommended in the construction of terraces in Texas*

Slope of land per 100 feet	Vertical fall between terraces		Horizontal distance between terraces	Slope of land per 100 feet	Vertical fall between terraces		Horizontal distance between terraces
Feet	*Feet*	*Inches*	*Feet*	*Feet*	*Feet*	*Inches*	*Feet*
2.......	2	0	100	7.......	4	6	64
3.......	2	6	83	8.......	5	0	62
4.......	3	0	75	9.......	5	6	61
5.......	3	6	70	10......	6	0	60
6.......	4	0	67				

TABLE 3.—*Spacings generally recommended in terrace construction*

Slope of land per 100 feet	Vertical distance or the drop between terraces		Horizontal distance between terraces	Slope of land per 100 feet	Vertical distance or the drop between terraces		Horizontal distance between terraces
Feet	*Feet*	*Inches*	*Feet*	*Feet*	*Feet*	*Inches*	*Feet*
1.......	2	6	180	7.......	4	0	57
2.......	2	9	140	8.......	4	3	53
3.......	3	0	100	9.......	4	6	50
4.......	3	3	80	10......	4	9	48
5.......	3	6	75	12½.....	5	4	43
6.......	3	9	63				

Disposal of Terrace Water

For many years it has been the custom in the South to turn water loose fro the end of a terrace to go where it will. Few have tried to hold terrace wat under control until it reached a stabilized drainage course. This neglect h resulted in severe damage to public roads as well as to farm lands. Estimat obtained from expenditure records of the Texas Highway Department showe that run-off from agricultural land and highways caused $1,566,540 damage the State road system in an 8-month period beginning in September 1935. Th figure does not include cost of repairs to county roads. Many miles of coun roads in the South, particularly in Oklahoma, have been damaged by run- from terraces and other drainage to the extent that it was necessary to reloca them at great expense. Deep gullies parallel to the roads made relocation nece sary as a public-safety measure. And water concentrated in roadside ditche from run-off from the road itself and from terraced fields, has destroyed mu good land when turned back into cultivated fields. But the principal dama caused by neglect of terrace-water disposal is incurred in the fields which t terraces are designed to protect. Gullies extending from terrace ends are common sight in the South.

In project areas of the Soil Conservation Service terrace water is held und control from the time it reaches the terrace channel until it is discharged into stabilized drainage course. After the water leaves the terrace ends, this control is effected largely by use of close-growing vegetation. If it is possible to do so, terrace water is turned into and spread over a well-sodded pasture field or an unburned, ungrazed woods on a moderate slope. In many instances, this cannot be done. It is sometimes possible, however, to extend a strip of pasture up the side of a field along the ends of the terraces and to relocate the fences to include this strip in the farm pasture, first establishing a good sod cover (fig. 8).

When pasture fields or woods are not conveniently located, or it is not safe to use them, the next-best plan to consider is the use of a meadow outlet strip. Most fields have depressions running through them which, if not terraced, would provide natural drainage. One such troughlike piece of land in a field may be converted into a meadow (fig. 9) or pasture strip by filling in trickle channels, preparing a seedbed, and seeding or sodding the area, using grasses adapted locally for hay or pasturage. On poorer soils, where growth would normally be slow, the outlet strip should be fertilized to hasten the establishment of a protective growth of vegetation. Whenever possible, the terraces should be built and the water turned on the strip after the vegetation is established, and not before. Meadow or pasture strips, which serve the double purpose of supplying forage and caring for terrace water, should be not less than 100 feet wide. The terraces should extend well into the outlet strip to prevent water cutting back and forming a gully along the edge of the cultivated part of the field.

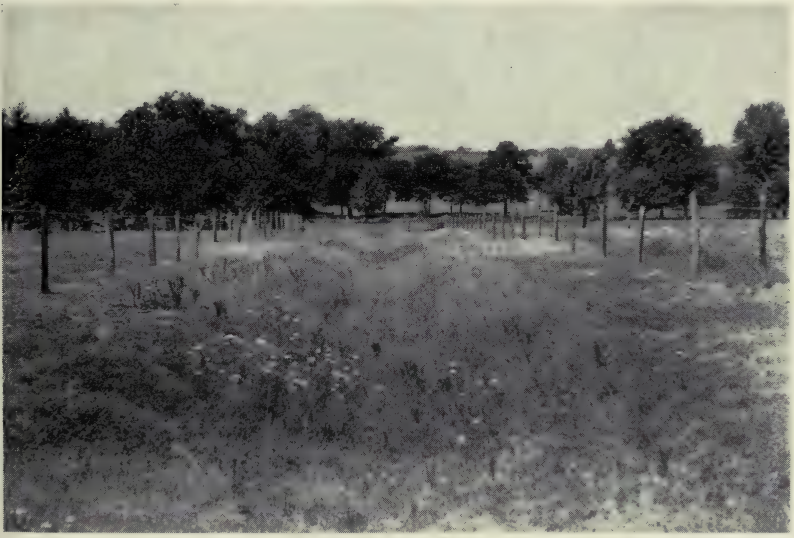


FIGURE 8.—*It is sometimes possible to extend a strip of pasture along the side of a field or through the center of it to take water from the ends of terraces, and to relocate fences to include the strip in the farm pasture, first establishing a good sod cover.*

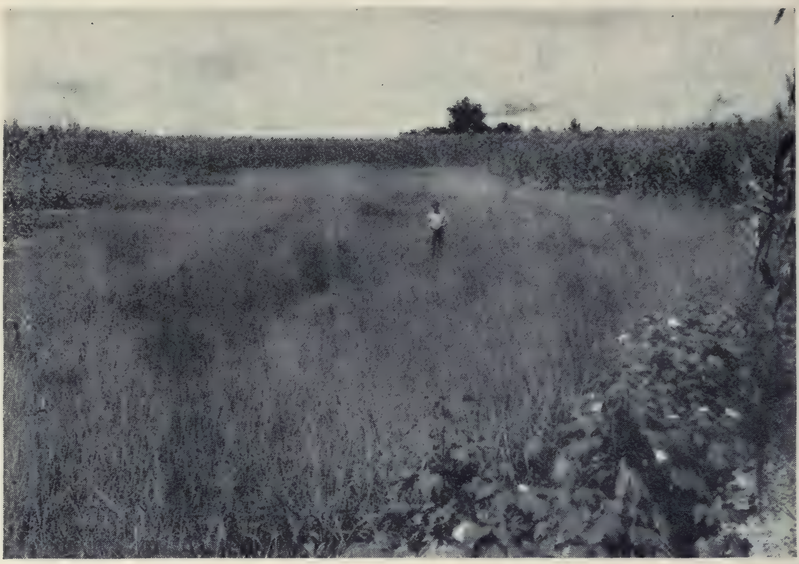


FIGURE 9.—*Water from terraced fields at the right and left is turned into this strip of meadow extending down a natural depression in the fields.*

Should none of these plans seem to meet conditions, it is necessary to build a sodded channel. Though sodded channels are satisfactory for erosion control, they are more expensive to provide. Sodded channels vary in width, depending on the size of the drainage area served by the outlet and the grade of the slope on which it lies. Little bottom width is required for terrace outlet channels on gentle slopes or where the drainage area is small. On steeper slopes and in channels serving large drainage areas the bottom width may be 18 or 20 feet. In many instances drainage water from more than 100 acres has been carried by properly designed and vegetated channels without apparent damage (fig. 10).

If the slope in the channel is not more than 4 or 5 percent, it is usually not necessary to sod completely. Except in Oklahoma, strips of sod spaced about 4 feet apart have proved able to withstand the heaviest rains on moderate slopes; in time, the sod

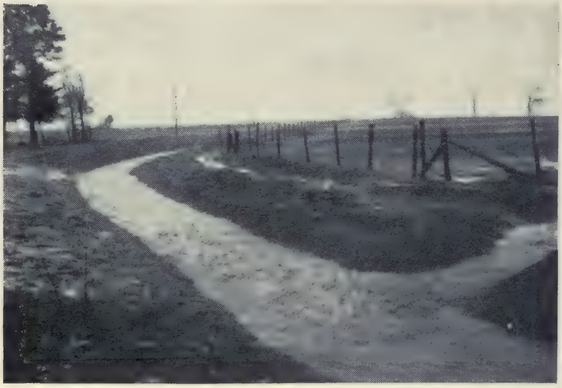


FIGURE 10.—*Water from more than 100 terraced acres has been carried safely to a stabilized drainage in sodded outlet channels.*

vill spread from strip to strip and cover the entire channel. Completely odded channels have been successful on slopes up to 10 or 12 percent. The od used in most project areas is Bermuda. Carpet grass provides full protection in some localities on the better-watered areas farther south. It is less esistant to cold than Bermuda grass. On the Temple, Tex., project in the lacklands buffalo grass is used in some outlet channels. In the project area at reenville, Ala., centipede grass is being used successfully.

When it is possible to divert terrace water away from the outlet channel emporarily or to build the channel before constructing the terraces, sodding nay be done more cheaply. Sprigs of Bermuda sod dropped in plow furrows n the channel, and fertilized, provide a dense cover more quickly and surely han strip sodding.

A strip of sod usually is placed across the channel at the end of each terrace o prevent scouring back from the outlet.

Contour Farming

Although contour tillage by itself seldom gives sufficient protection to control oil washing except on moderate slopes, it is invaluable as a companion measure o all other defenses. Unless terraced land, for example, is contour-cultivated, he useful life of the terrace system is very short if the land is planted to row

IGURE 11.—*Under a system of contour farming all rows in a field follow horizontal lines around a slope. Field operations following the contour throw up ridges of soil which confine rain water. Contour cultivation is invaluable as a companion measure to terracing and strip cropping.*

crops. It is impossible to maintain terraces satisfactorily in fields that are not contour farmed. The down-slope movement of soil between terraces is too great, and the channels quickly fill. Only in country new to terraces do farmers attempt to cultivate across them rather than with them. Cross cultivating is usually abandoned as a result of experience.

Under a system of contour farming (fig. 11) all rows in a field follow horizontal lines around a slope. Field operations following the contour throw up ridges of soil which confine rain water. Water cannot flow downhill until the ridges are overtopped, which occurs only after considerable rain has fallen. But the rains of high intensity and long duration are the ones that cause the greatest soil movement, and contour cultivation therefore fails as a single measure when the land most needs protection. As a lone defense measure, contour cultivation coupled with a sound rotation may be relied upon to control erosion only on gentle, smooth, short slopes with a fall of not more than 1 or 2 feet in 100. Such slopes are rare. Most cultivated slopes in the South must be terraced or strip-cropped or terraced and strip-cropped and planted in proper rotation if erosion is to be arrested.

Contour tillage saves moisture. During the lighter rains the furrows and rows hold most of the rain water where it falls, which helps to bring a crop through the long and sometimes droughty summers of the Cotton Belt. Moisture-penetration tests strikingly illustrate the value of contour tillage as a water-conservation practice. In one test after a series of fall rains on the upper Concho River watershed in Texas, where moisture is regularly a limiting factor in crop production, land that was contour-tilled held approximately three and one-half times as much available moisture for plant growth in the upper 5 feet of soil than land of the same slope on which the rows ran downhill.

Strip Cropping

When the practice of stip cropping engaged the popular fancy a few years ago the idea was thought to be new. It has since been learned that for years some farmers in parts of Ohio, Pennsylvania, West Virginia, Wisconsin, and the blacklands of Texas have been planting strips of erosion-resisting crops between strips of clean-tilled crops to control erosion. A community of farmers in Ohio has followed the practice for almost a quarter of a century. But in most of the Cotton Belt, where farmers early became engrossed with contour tillage and terracing, hardly more than half a dozen years of trial lie behind this newest defense measure. Country-wide trials on more than a million acres, however, have demonstrated the value of the practice as a companion measure to contour tillage, with or without terraces.

As we have seen, crops differ widely in their ability to hold soil. The practice of strip cropping recognizes these differences, and takes advantage of the superior soil-holding and water-filtering properties of densely growing plants to retard soil washing. In a strip-cropped field two or more crops are grown rather than one. The close-growing crop, which is called the control strip, is planted around the slope, on the contour like a terrace, between bands of clean-tilled crops. Placed in this position, the stems of the densely growing plants obstruct the flow of run-off from land in erosion-permitting crops like cotton and corn, checking the velocity of the water so that soil particles settle out in many tiny slack-water pools.

Well-grown control strips catch a surprisingly large amount of soil. During heavy rains it is not uncommon for a control strip to collect several inches of soil (fig. 12) near its upper edge where the strip crosses a depression in the field. Toward the center of the strip this soil layer becomes shallower and may shade to a trace at its lower edge. In field trials most of the soil has been caught in the upper 12 feet of the strip. After it is freed of its soil load, much of the water passes into the soil in moving across the rest of the strip.

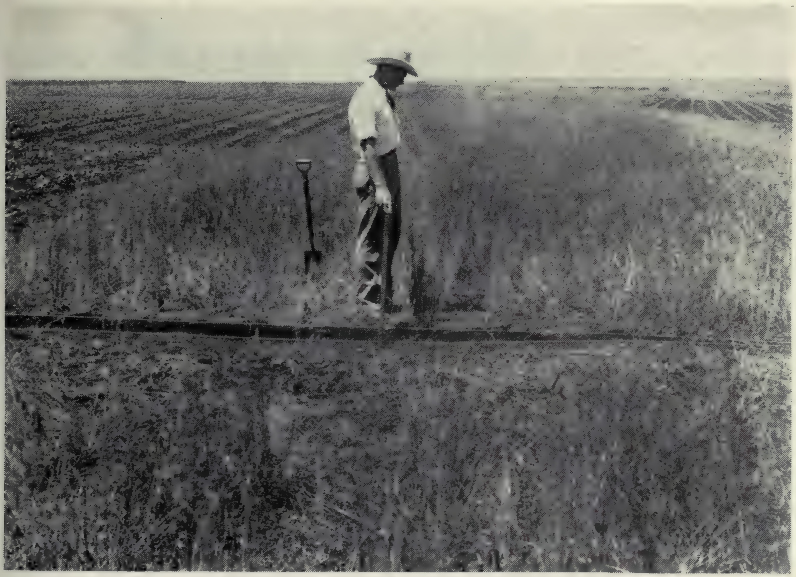


FIGURE 12.—*It is not uncommon for a close-growing strip crop to catch several inches of soil near its upper edge during heavy rains. The layer of soil shown here between two lines settled out of the run-off from the area above planted to cotton.*

Experimental trials with strip cropping sometimes produce surprising results. In a trial at the soil and water conservation experiment station at Temple, Tex., in 1934 and 1935 the plot planted in cotton on the contour lost almost 10 times as much soil as the plot protected by contour strips. The rate of loss from the strip-cropped plot was 12.3 tons for the period; the loss from the all-cotton plot was at the rate of 118.6 tons. The plots at Temple lie on a 4- to 6-percent slope. The station is located on typical Houston clay in the heart of the Texas blacklands. Oats seeded in the fall is the crop used in the control strips in the experiment. The oats are followed by hairy vetch for green manure, and the land is later bedded for cotton.

Soil under a close-growing crop, as we have said, absorbs water more readily than soil planted to tilled crops. This accounts for much of the erosion-resisting effect of strip cropping. Results at the Temple station illustrate this point During a 3-inch rain in April 1936, less than 5 percent of the rainfall left a strip-cropped plot as run-off, while a plot without strips lost 57 percent of the precipitation. It can readily be seen that the large number of stems retard the speed of flow, which gives more time for water to soak into the ground. But this is perhaps not the principal reason for the superior water-holding properties of the land in strips. The explanation seems to rest on the fact that the close-growing plants obstruct and clarify the muddy water, and then the water, made clear penetrates into the soil more readily.

On entering a strip, water spreads out fanlike, its velocity is checked, and it drops its soil load. Because water gravitates to the lower-lying places, these receive more of the silt deposit, and fill in, which tends to smooth surface irregularities in fields. Irregularities in the surface of clean-tilled land, on the other hand, become more pronounced and grow into gullies, owing to the quickened flow of the concentrated water as it passes down depressions in a field.

The close-growing crops most commonly used in a strip-cropping plan between strips of row crops are the small grains, winter legumes, and the forage crops although occasionally a special crop like crotalaria is used. Oats or other small grains are used over most of the Cotton Belt for winter protection. After the oats are harvested, either for hay or for grain, the stubble is left standing for continued protection or is turned under, to be followed by a summer strip Sorghum or Sudan grass or a mixture of either of these with cowpeas usually succeeds the small grain. Hubam sweetclover, a recently introduced annua white variety, is gaining recognition in the Texas blacklands for use in strips Common and Korean lespedezas are used widely in project areas east from eastern Texas and Oklahoma. For strips that are to stand more than 1 year little bluestem, *Lespedeza sericea*, kudzu, alfalfa, and sweetclover are popular in certain localities. Of these, *L. sericea* and kudzu have the widest range of usefulness east of the Mississippi River. The use of little bluestem is confined to the prairie lands of Texas and Oklahoma; it is particularly well adapted to the black-belt soils of Texas. Alfalfa and sweetclover are recommended only for soils most favorable for their growth. These strips of biennial and perennia plants are especially recommended for certain steep slopes, or steep parts of otherwise moderate slopes, which require more continuous protection than strips of annual plants can give.

Like other soil-defense measures, strip cropping is not a cure-all; and it is not recommended as a substitute for terracing except on short gentle slopes. After several years of trial, the soil and water conservation experiment station at Guthrie concludes: "Strip cropping is an effective means of conserving soil on moderate and ungullied slopes but does not afford sufficient protection on gullied or steep slopes." In project areas of the Soil Conservation Service, strip cropping is used most often as a companion measure to terracing (fig. 13). The two defenses, one supporting the other, go well together. Strips of close-growing crops on terraced land help to prevent excessive washing of the soil between terraces, which aids incidentally in preventing the clogging of terrace channels and lessens the cost and difficulty of maintenance. Close-growing crops placed astride terraces protect them from failing during periods of excessively rapid run-off; also, cultivation of terraces the first year, before they have settled, tears them down. Short point rows may be avoided by widening the strips to include the areas these normally occupy.

On land affected by sheet erosion only, strip cropping, contour tillage, and crop rotation are employed without terraces, in project areas. Gullied fields are given the fuller protection afforded by a combination of these three measures with terracing.

It has proved unwise in the Soil Conservation Service project areas to depend for erosion control altogether on a system of strip cropping without terraces

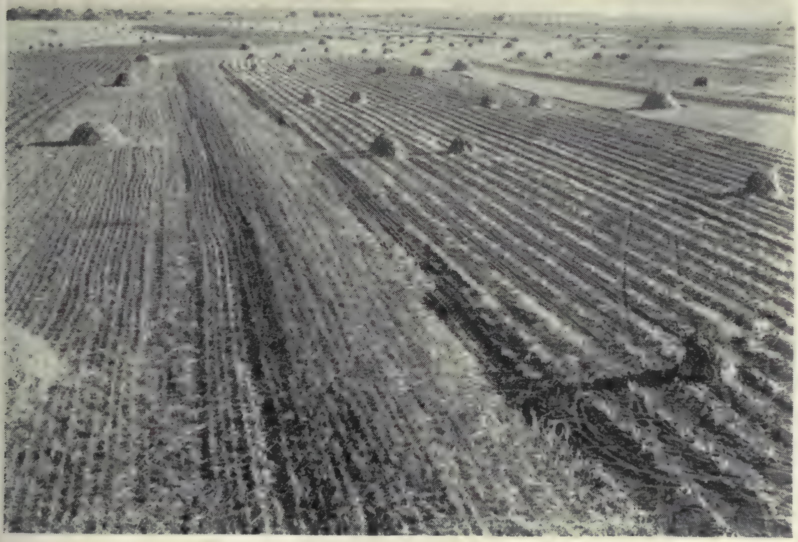


FIGURE 13.—*In project areas of the Soil Conservation Service, strip cropping is used most often as a companion measure to terracing. The two defenses, one supporting the other, get along well together.*

on slopes that are long even though gradual. Long slopes receive tremendou quantities of water during the heavier rains, and it is usually necessary, especiall where the soil takes up water slowly, to provide surface drainage by a syste of terraces. Often in such instances, the upper part of the slope is strip croppe and terraced and the lower part strip cropped only.

There are several different kinds of strip-cropping plans in use in the Cotto Belt. The plan that is selected is determined by a number of factors: The slop of the land, the degree of erosion, the crops adapted to the locality, the need o

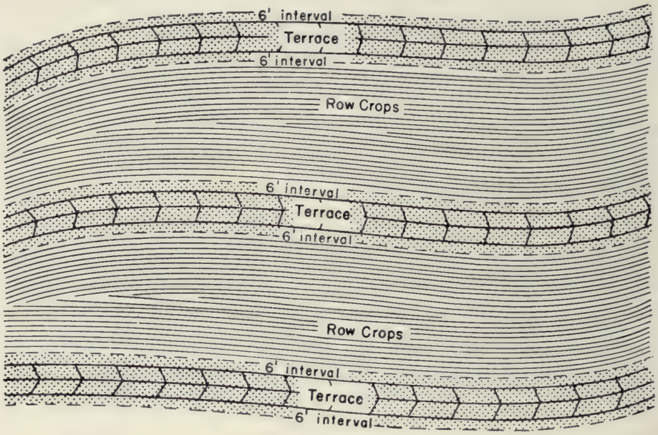

6' interval
Terrace
6' interval
Row Crops
6' interval
Terrace
6' interval
Row Crops
6' interval
Terrace
6' interval

FIGURE 14.—*This method of strip cropping is used to protect newly made terrace during the settling period. The width of the strip is uniform, extending from feet above to 6 feet below the terrace.*

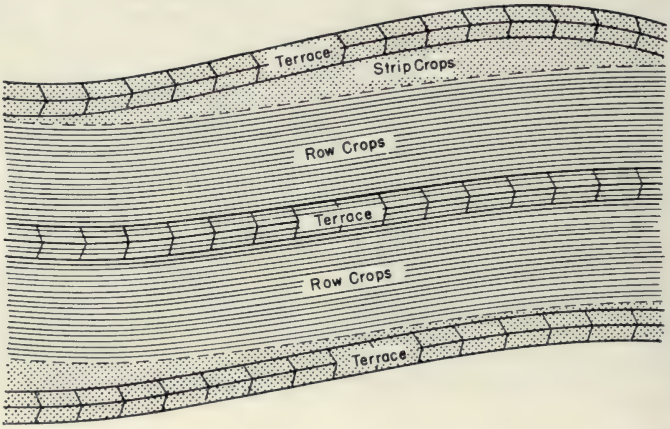

Terrace
Strip Crops
Row Crops
Terrace
Row Crops
Terrace

FIGURE 15.—*In this method of strip cropping, close-growing vegetation is plante on every second terrace. The control strip extends as far as necessary to take u the short-row area.*

the farm for forage, the soil type, the necessity for maintaining a balance between cash and other crops—among others. Further on in this bulletin, in a section entitled "Recommendations by Regions," control practices for the major agricultural divisions of the Cotton Belt are discussed in more detail; included is some further mention of local adaptations of the strip-cropping principle.

On terraced land the spacing of strips is adjusted to the spacing of the terraces. The arrangement of strips used with terraces is explained in the legends under the diagrams in figures 14 to 19. The width and spacing of strips on unterraced land is still a debated question. As a tentative recommendation for the South,

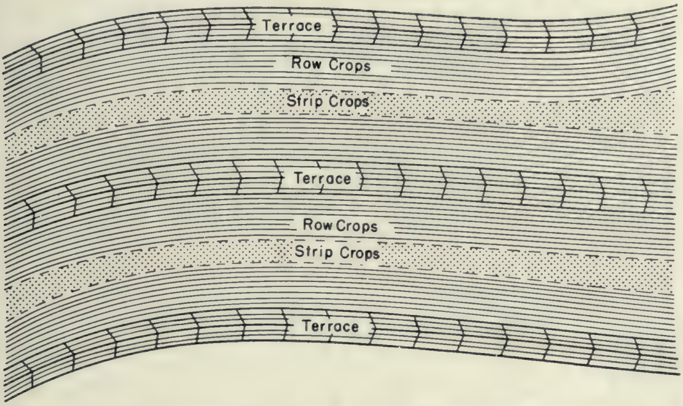

Terrace
Row Crops
Strip Crops
Terrace
Row Crops
Strip Crops
Terrace

FIGURE 16.—*Here the erosion-control strips are placed in the center of the terrace interval. Their minimum width is 12 feet. They are widened when necessary to take care of the short-row area.*

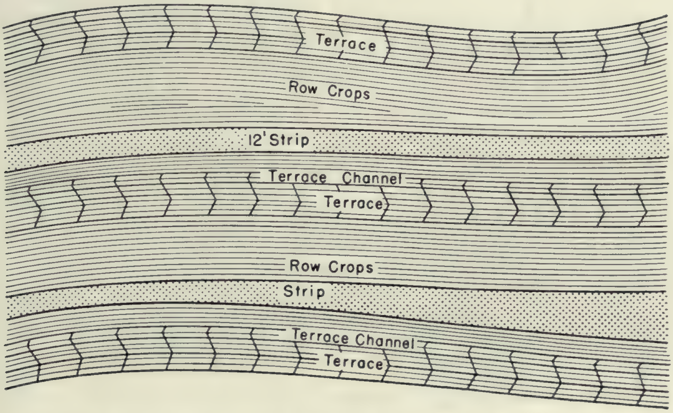

Terrace
Row Crops
12' Strip
Terrace Channel
Terrace
Row Crops
Strip
Terrace Channel
Terrace

FIGURE 17.—*Here the control strip is located just above the terrace channel. The minimum width is 12 feet. If the short-row area is not included in the strip, the short rows are made to fall in the center of the interval between terraces.*

the following width and spacings have been advanced: About 25 feet of close-growing crop for each 100 feet of slope length on land that rises not more than 3 feet in 100; about 35 feet of close-growing crop in each 100 on slopes rising 3 to 5 feet in 100; at least half of the area in close-growing crops, in strips about 50 feet wide, on steeper slopes.

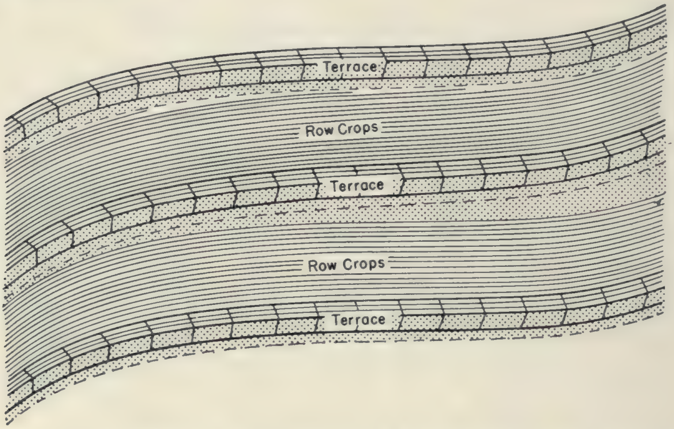

Terrace
Row Crops
Terrace
Row Crops
Terrace

Figure 18.—*Here the control strip begins on the terrace ridge and extends at least 6 feet below the base of the terrace. The control strip is widened when necessary to take up the short-row area.*

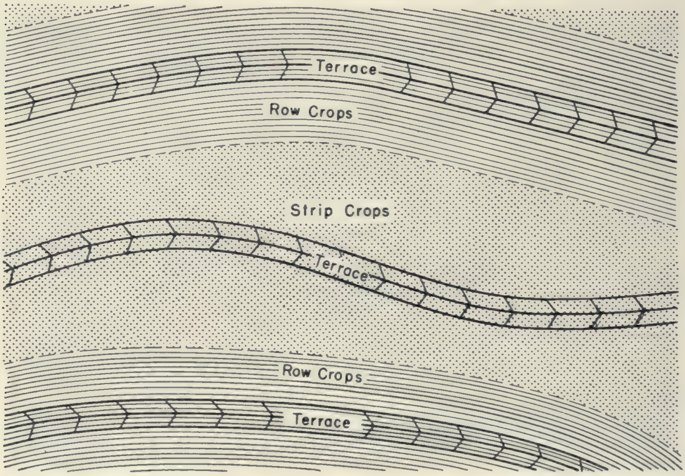

Terrace
Row Crops
Strip Crops
Terrace
Row Crops
Terrace

Figure 19.—*The control strips are placed astride alternate terraces in this method. The control strip begins in the middle of one terrace interval and extends over the terrace into the middle of the terrace interval below. It is widened to take care of the short-row area.*

Border Strips

The use of border strips of close-growing fibrous-rooted crops seems a natural development of the strip-crop idea. The function of border strips is to protect places in a field that are especially vulnerable to erosion when planted in row crops, such as, for instance, the borders of fields, drainage ditches, terrace-outlet channels, and roadside ditches. Used in connection with a strip-cropping program, as they are most frequently, border strips provide a convenient tie between contour strips and space for turning, which aids in planting, cultivation, and harvesting operations. Usually the same crops are used in the border strips as occupy the field strips, although some farmers use woody shrubs bordering particularly hazardous locations, such as deep cuts along roads, ditches, or gullies. Shrubs providing food for wildlife are selected.

Green-Manure and Cover Crops

The lighter colored, sandier soils in the cotton country generally lack sufficient organic matter, having developed under forest cover. Continuous clean tillage and the climate have further reduced the supply. After a row crop is harvested there is little plant material to turn back into the soil to replace the organic matter carried away by run-off and used up by plant growth and decay during the growing season.

This lack of organic matter in the lighter colored, sandier upland soils is known to be one of the principal reasons they wash more readily than other soils; it also helps to explain why subsoil materially usually washes more rapidly than topsoil. Decaying plant parts and humus hold soil particles together. To say that the action of organic matter in soil is like that of cement in concrete is not a too-careless comparison. Organic matter, as humus, combines the coarser and finer soil particles into aggregates which are more resistant to washing than particles finely separated.

Erosion begins slowly on land freshly broken from grass or from forest. This is because of the presence of accumulated organic matter in the soil. Soil leaves new fields a little at a time at first, in very thin sheets, with each rain of sufficient intensity to cause sheet wash, and the rate gradually increases as the supply of organic matter becomes depleted. Once the upper layer, which contains proportionately more organic matter than the soil underneath, is cut through, the rate of erosion becomes rapid, and gullying begins. Erosion goes forward exceedingly rapidly into the subsoil, which contains little organic matter.

The most practical way to replace lost organic matter is to grow crops of green manure, preferably legumes. When a well-grown green-manure crop is turned under, several tons of vegetable material (fig. 20) to the acre is added to the soil, which greatly improves its physical condition and enables it to take up and hold larger quantities of water in a way favorable to plant use.

In the Cotton Belt green-manure crops may be grown either in summer or winter. Fortunately, the South may depend on a number of legumes for cover crops for green-manuring purposes. These may be planted in rotation with cotton and corn. Vetch is adapted to a great part of the South, and Austrian Winter peas likewise may be used widely. Hubam sweetclover is growing in favor for green-manure purposes in the blackland and Grand Prairie sections of Texas. Bur-clover and crimson clover are acquiring prominence as winter cover crops in parts of the South. For summer use there are cowpeas and velvetbeans, which are now grown in many localities in alternate rows with corn.

Experiments with cover crops in the South conclusively prove the value of these legumes in a soil-improvement program when turned under for green manure. Amazingly better yields of cotton and corn have followed their use in rotation with these row crops. Alabama investigators state that turning under vetch or Austrian Winter peas increased corn yields 18 bushels an acre at a cost of 14 cents a bushel, in a series of experiments.

Green-manure or cover crops, besides affording winter grazing for livestock and supplying organic material to the soil, are also directly helpful in controlling erosion. They provide cover for fields which otherwise would be bare of vegetation during seasons when erosive rains commonly occur. Over a great part of the Cotton Belt damaging rains cause severe soil washing during the winter months. In these extensive areas cover crops of vetch, winter peas, crimson clover, and bur-clover are invaluable in reducing erosion rates in this season of

FIGURE 20.—*Turning under well-grown cover crops adds organic matter to the soil. Soil charged with organic matter is in good physical condition to resist erosion. It can take up and hold large quantities of water in a way favorable to plant use.*

the year. In southern Oklahoma rye, barley, mixed seedings of rye and vetch, and some soft winter wheat are used for winter cover crops, and pastured. These are broadcast following cotton, corn, or grain sorghum.

Continuous Use of Close-Growing Cover

Slopes that still retain a portion of their topsoil but, owing to soil type or excessive grade, are especially susceptible to erosion, are frequently made into permanent meadows or kept continuously in close-growing, fibrous-rooted crops, in project areas. Several crops used for this purpose deserve special mention.

Kudzu, particularly in the eastern half of the Cotton Belt, is used widely as forage crop on these so-called critical slopes. Kudzu does well even on severely eroded land where there is ample moisture. It is a strong-growing legume that spreads by runners that sometimes attain a length of 35 feet or more in a single season. Kudzu meadows are established by setting out about 1,000 crowns, seedling plants, or vine cuttings an acre. Cultivation is necessary during part of the first season to eliminate competing vegetation. In a year or two the kudzu plants cover the ground completely. On eroded land a shovelful of manure should be placed beneath each crown.

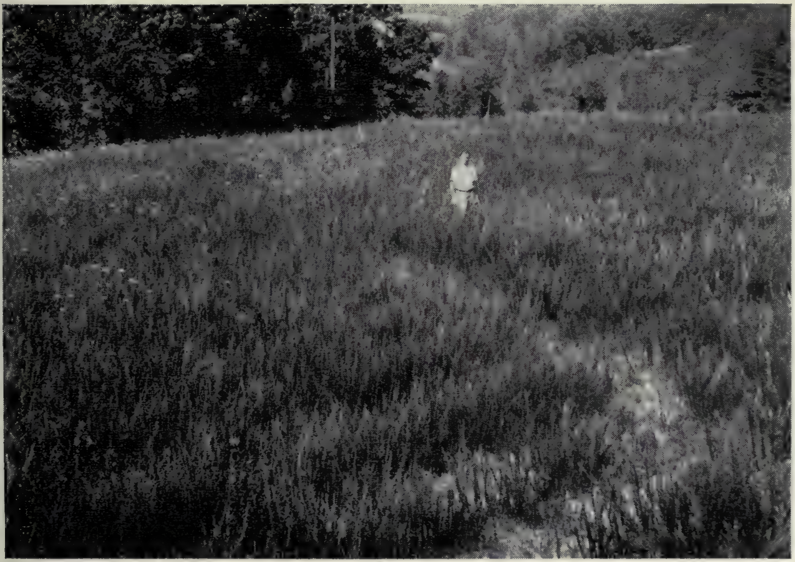


Figure 21.—*Many eroded hillsides are retired from the production of row crops and planted in crops that provide continuous cover for the land. Lespedeza sericea is used widely and successfully for this purpose east of the Mississippi River. This stand is 3 years old.*

Lespedeza sericea has a wide range of usefulness throughout much of the Cotton Belt. It is an excellent erosion-resisting plant, is a legume, and makes excellent forage when properly handled. A perennial lespedeza, it is especially desirable for use on vulnerable slopes (fig. 21).

In the southern part of the Texas blacklands there are communities of farmers of German and Bohemian extraction who have kept their more erodible slopes in native meadow. The meadows are usually made up of a mixed stand of little bluestem, big bluestem, and Indian grass. In project areas in the blacklands of Texas this meadow mixture is seeded on slopes that are too steep for growing row crops safely.

A rotation used on especially vulnerable slopes in some areas is oats followed by Sudan grass. The oats are harvested either for forage or grain; the Sudan grass is used for temporary pasture. Since seedbeds are prepared regularly for these crops, slopes designated to be planted in "continuous broadcast" are terraced to prevent excessive soil losses should erosive rains occur while there is no protective cover of vegetation.

Converting Cultivated Fields to Pasture

Perhaps much of the eroding land in the South that is now planted to row crops would, in the long run, yield more profit with less effort if it were made into pasture. Certainly this is the case with the steeper slopes—slopes that are losing too much soil to remain long in profitable cultivation. As a soil conservation measure in project areas, many of these slopes are retired from cultivation and planted to grass, where the soil is suitable for pasture purposes.

In the majority of instances Bermuda grass is used for the pasture base. Several methods of planting are employed to establish Bermuda grass. One is to flat-break the land on the general contour with a turning plow, dropping roots or chunks of Bermuda sod at 3- to 4-foot intervals in every third or fourth furrow. The sod is covered by the succeeding round of the plow. Another method is to run furrows on the general contour with a small lister or a large shovel plow at 4- or 5-foot intervals. The roots or sod pieces are dropped 3 or 4 feet apart in the furrows and covered with another light furrow, a drag, a broad wheel, or a two-shovel cultivator (fig. 22).

Bermuda sod spreads extremely slowly unless it is cultivated. When Bermuda grass is cultivated between the rows runners may almost cover the ground in a single season. Cultivating is done in the early spring while the soil is moist; cultivating when the soil is dry damages Bermuda grass. A disk cultivator does good work, but when it is not available ordinary cultivating implements may be used instead. The idea is to work up enough loose soil to permit the runners to catch hold. Established Bermuda-sod pastures should be cultivated at intervals of about 3 years. It is a good plan to cultivate about one-third of the pasture each year.

IGURE 22.—*Where the land is suitable for the purpose, slopes which are losing too much soil under cultivation may be made into pasture. Fifteen men working with seven teams sodded 200 acres on this farm in 5 days, using Bermuda grass roots.*

In some project areas in Arkansas and Oklahoma Bermuda sod for pasturage as been established successfully by planting it in rows with corn or cotton. he cultivation of the row crop cultivates the Bermuda grass. This method ermits production of a crop while the sod is becoming established.

Where there is danger of heavy soil losses before the sod becomes established, light seeding of oats, rye, wheat, or any temporary grass is made after the odding operation to give immediate erosion control. In season, overseedings of dapted grasses and legumes are sown to thicken the cover and to provide a more-alanced pasture mixture and a longer pasture season, except where competition r moisture is too keen. Most upland soils must be fertilized and limed before ie clovers will thrive; in fact, in most of the South, east of the Texas blacklands, ertilization is considered more important than any other practice in establishing ood pasture. Other measures are ineffective in helping to establish cover if ineral plant foods are lacking.

On some lands, usually the moist soils, carpet grass is the pasture base. The ethods of establishing carpet grass sod are like those used for Bermuda grass. n the prairie sections, where there is less annual rainfall, buffalo grass is used for asture development where sod is available. In establishing buffalo grass pas- ure, furrows are opened, into which sod is dropped, roots down, and pressed nto the soil. Soil is pulled around the sod. Buffalo grass sod is not covered.

Pasture Management for Erosion Control

The cover of vegetation in many pastures is too poor and sparse to check erosion effectively. This is especially true of pastures grazed too early in the spring or too heavily during the pasture season. Where Bermuda grass is the pasture base, grazing should be close enough to prevent high growth. Kept low the runners cover more ground, and the grass is more palatable to stock. For erosion control, therefore, as well as for the general improvement of the pasture itself, it is necessary to manage the pasture so that the cover of desirable plants will thicken and remain intact. A variety of practices are employed in project areas to accomplish this.

Control of Weeds

Many of the better pasture grasses and clovers cannot thrive in the shade Bermuda grass is especially prone to die out when shaded by weeds or brush The brush should be removed, except on stream banks or other drainageways with well-defined channels. Weeds may be controlled by mowing or pasturing with sheep and goats. It is not exaggerating to say that pastures may be made with a mowing machine and fertilizer in some of the more humid areas of the Cotton Belt. Several mowings each year may be necessary while the pasture is weedy. However, such weeds as the bitterweed should not be cut low when young, as this induces multiple branching and low fruiting. A low cutting in August may be necessary. In central and western Texas one close mowing in late July or early August as broomweeds begin to bloom has controlled this weed except in wet years, when two mowings are necessary. Pasturing heavily with sheep when the particularly bothersome weeds are very young is effective where this class of livestock is raised.

Overseeding Pastures

Overseeding a pasture with legumes and supplementary grasses not only aids in erosion control by filling in the voids in the turf but lengthens the pasture season. If a Bermuda grass pasture is overseeded with hop clover and lespedeza, for example, the pasture is made to produce forage earlier in the spring. Bermuda grass is one of the last of the grasses to become ready for grazing in the spring. The hop clover is ready first, the Bermuda grass next, and then, for the summer season, the lespedeza.

Supplemental Feed

Seasonal relief to permanent pastures, to eliminate damage by overgrazing and to permit the pasture plants to mature seed, is provided in project areas, (1) by he production of ample supplies of winter feed in strip crops and meadows, and 2) by establishing temporary pastures. When adequate feed supplies are available, it is not necessary to turn livestock out on pasture until the pasture is ready or grazing. Temporary pastures will provide relief during both summer and vinter. Such crops as Sudan grass, soybeans, millet, and sweetclover are used o provide summer pasture, and the small grains, vetch, winter peas, and Italian yegrass for winter pasture.

Pasture Furrows and Ridges

Pasture furrows and ridges serve several purposes. They help to hold soil, eed, and water in the pasture, thus aiding vegetation in becoming established fig.23). In the earlier field work of the Soil Conservation Service in the Cotton elt, ridges rather than furrows were used in pasture-improvement programs. More recently, however, the trend has been away from the use of ridges toward he use of shallow furrows. It has been found that furrows, which are more losely spaced than ridges, give better distribution of water over the surface of he land and more uniform aid to vegetation than ridges. Also, a furrowed asture may be mowed more easily than a ridged pasture.

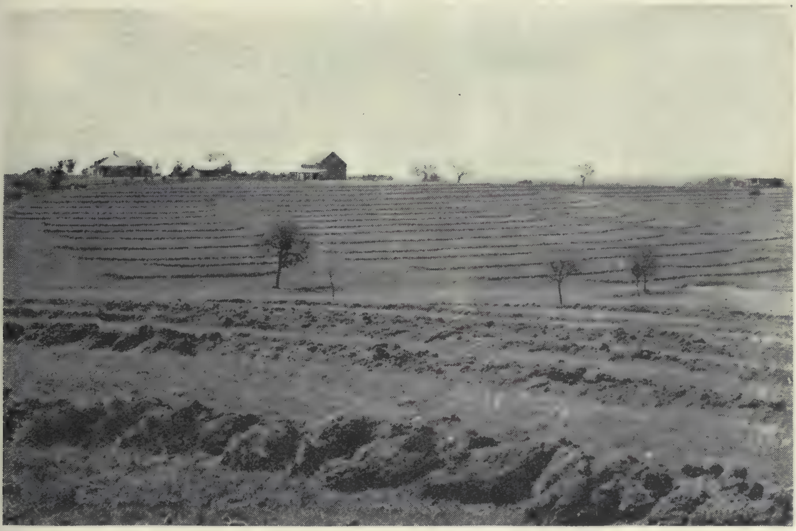


FIGURE 23.—*Ridges and furrows hold soil, seed, and water in a pasture, thus aiding vegetation in becoming established.*

The contour ridge resembles a miniature absorption terrace. It is built on the ontour around a slope with two rounds of a long-wing plow, and the ends are turned uphill to prevent wastage at these points of the water that collects behind the ridges during periods of run-off. The ridges are turned uphill also before crossing washes or draws in the pasture. Ridges are spaced 12 to 20 feet apart on a slope.

Contour furrows are spaced 5 to 7 feet apart on a slope. They also follow the contour. Some are made with one through of a walking plow; others with one through with an ordinary plow followed by a long-wing plow. The furrow slice is thrown either uphill or downhill. All pastures in project areas where the average rainfall is low or where the rain is poorly distributed through the pasture season, are contour-ridged or furrowed. Moisture conservation in such areas is of utmost importance. In areas of greater rainfall and where the rainfall is well distributed through the growing season, they are constructed on long slopes of even conformation where the turf is thin. Contour ridges or furrows also are used to hold water away from gullied areas in old permanent pastures and in permanent pastures lying above cultivated fields.

On steeper, irregular slopes it is difficult to hold to an exact contour line. Should the completed furrow or ridge deviate from the contour, its water furrow may be blocked at 50-foot intervals with a few shovelfuls of soil.

Converting Fields to Woods

Much of the cropland retired from cultivation in project areas is planted to trees, in those parts of the Cotton Belt where trees are adapted. Forest cover, as previously mentioned, is the most stable type of cover for soil protection. On most farms in the humid areas of the Cotton Belt there is much land too steep or too badly eroded to be suitable for row crops, meadow, or pasture. Where there is sufficient depth of soil, planting such areas to trees brings the land back into productive use. Even on many farms where all of the soil is suitable for other purposes, space may be profitably set aside for a farm woods, for often a farmer can produce his own fuel, posts, poles, and building timber more cheaply than he can buy them. Foresters estimate that in northern Louisiana, for example, 15 acres of woods is required to meet the day-to-day needs of the average farm for wood products.

The South as a whole has advantages for growing crops of timber hardly equaled elsewhere in the United States (fig. 24). The southern pines as a group rank among the most rapidly growing tree species. Loblolly, shortleaf, and slash are the pines planted in most project areas. However, clumps of hardwoods are included in the larger plantings of pine. This creates a type of leaf litter that improves soil-moisture conditions, prevents the soil from becoming too acid, and increases the activity of soil organisms. Mixed stands are more valuable to wildlife. Pine woodlands therefore are often edged with hardwood trees and shrubs to encourage birds. Hardwoods are set out only on carefully selected sites in suitable soil. There is evidence that the presence of black locust among other hardwoods stimulates the growth of the slower growing, onger lived hardwood trees. Plantings of black locust, owever, are often made in ure stand for fence-post roduction (fig. 25). The lack locust is an excellent ree to plant behind check ams in gullies, where the oil is loose and moist. lack locust will grow fairly vell in poor soil, but it has een found necessary in roject plantings to cultivate the trees for the first ear at least. Small black ocust seedlings are like orn seedlings; they need arly, shallow cultivation o keep weeds down and to oosen the soil. Two cultivations are considered ufficient. Cultivation late n the season, however, eacts unfavorably. An pplication of fertilizer is of ourse helpful. On the etter soils black locust rees have grown to fence-post size in 8 or 10 years.

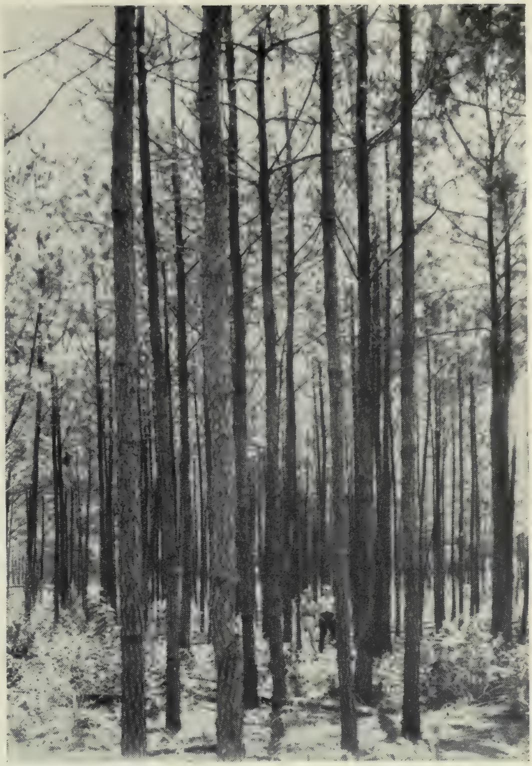


FIGURE 24.—*The South as a whole has advantages for growing crops of timber hardly equaled elsewhere. This young pine woodland has been thinned and pruned to permit better growth by the desirable trees.*

Woodland Management for Erosion Control

When the excellence of forest cover as a protection for the soil is emphasized, the reference is to woods in which the ground cover of vegetation and leaf litter are undisturbed by grazing or fire. It is a common practice in the South, no doubt owing to a general lack of good open pastures, to graze the farm woods; and many farmers set fire to their woods each spring. These practices combine to reduce materially the value of the stand of timber and the erosion-resisting value of the woods' cover.

In project areas the farm woods is protected from grazing by fencing, where necessary, and from fire. A provision in the cooperative agreement between the farmer and the Government calls for protection of woodlands and forest plantings from damage by grazing. Firebreaks are constructed to protect woodlands where an unusually high fire hazard exists. Firebreaks are designed to stop or check fires that may occur and to be used as a line from which to work in fighting fire. A firebreak may be either a natural or constructed barrier or a combination of these. Thus a firebreak system may include a road, a stream, a cleared field, a wide trail, a closely grazed pasture, all connected by specially prepared strips made free of burnable material. Smaller woodlands may be protected adequately by constructing firebreaks along the woods' boundaries where the fire hazard is exceptionally high, such as along public roads and railroads.

After reforestation of retired land has been provided for, and the control of fire and grazing in woodland, a plan of woodland management is prepared for each cooperator in project areas, and the initial steps in executing the plan are demonstrated. The objectives of management are (1) to increase the proportion of valuable species in the stand and (2) to provide for an orderly system of harvesting crop trees that maintains a full stand of trees for erosion control and water conservation and assures the owner of maximum yield from his woodland. The particular procedure followed to accomplish these objectives varies from farm to farm, according to varying soils, financial limitations, needs for wood on the farm, present condition of the woodland, and availability of markets. In badly deteriorated woodlands from which the better species have disappeared entirely as a result of long-continued abuse, interplanting the scrub stand with trees of desirable species is sometimes resorted to.

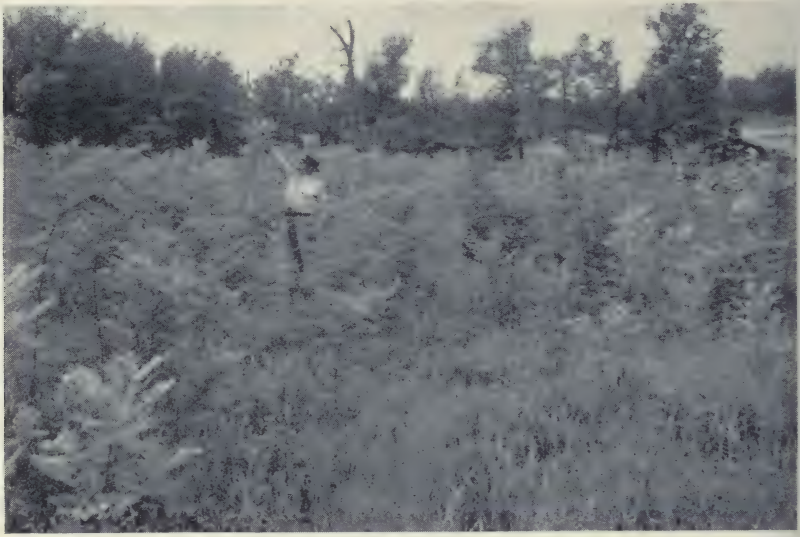


FIGURE 25.—*Within 13 months after black locust trees were planted erosion was brought under control on this slope which had lost three-fourths of its topsoil and some subsoil while in cultivation. Black locust makes excellent fence posts.*

Wildlife Plantings

While planting to control erosion, it is often possible and always desirable to use plants that provide food and cover for the various species of wildlife one wishes to protect and encourage.

Almost any type of vegetation used to control erosion is of some value for wildlife. Strip crops, winter cover crops, tree plantings, woodland-conservation practices, all contribute to the improvement of the wildlife habitat.

In working out a complete erosion-control and improved land-use program for each farm, many small areas are found which may be devoted strictly to wildlife plantings. Wildlife plantings are of various kinds. Often small eroded corners of fields, steep slopes in cultivated fields, badly eroded boundary areas between cultivated fields and woodlands are planted to *Lespedeza sericea* and common lespedeza, browntop millet, and, in many cases, to low-growing shrubs such as blackberry, hog plum, coralberry, and hedge privet (fig. 26). Lespedeza and shrubs are frequently planted in gullies or in thin soil in pastures.

Trees especially useful for wildlife support are the red cedar, dogwood, mulberry, hickory, pecan, black cherry, most kinds of oak, sumac, hackberry, black gum, beech, red gum, and walnut, which bear food for squirrels and birds. These may be planted in single and double rows on the outer borders of new woodlands, thus providing diversified foods, nesting sites, and coverts for various species of wildlife. Likewise gullies in woodland edges are planted to legumes and shrubs for the same purpose.

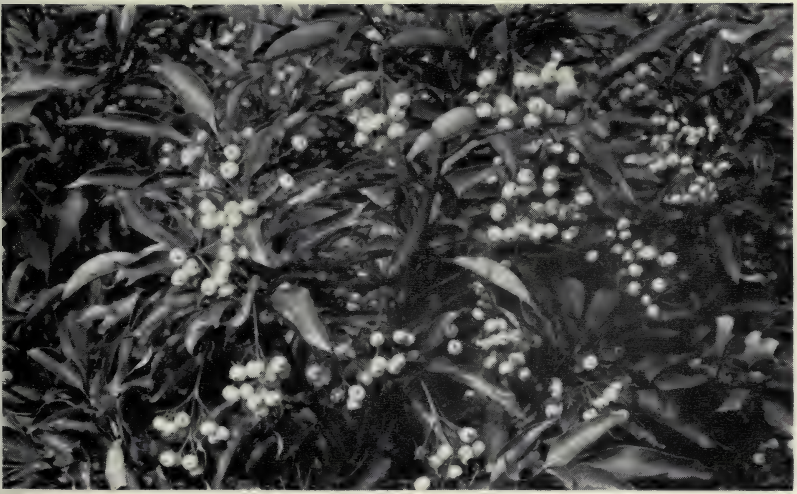


FIGURE 26.—*It is often possible and always desirable to choose plants for erosion control that provide food and cover for the species of wildlife one wishes to encourage. The shrubby dogwoods have a wide range of usefulness in the South.*

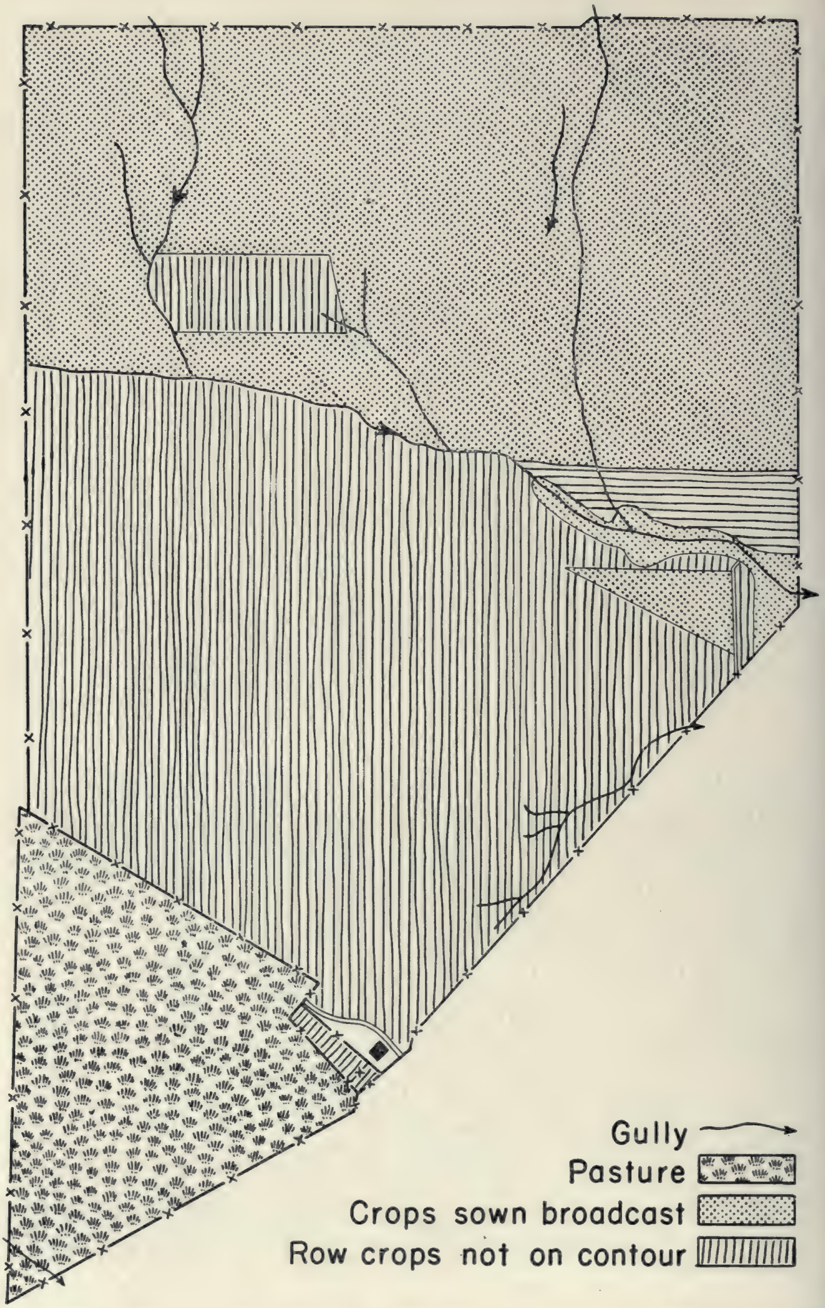
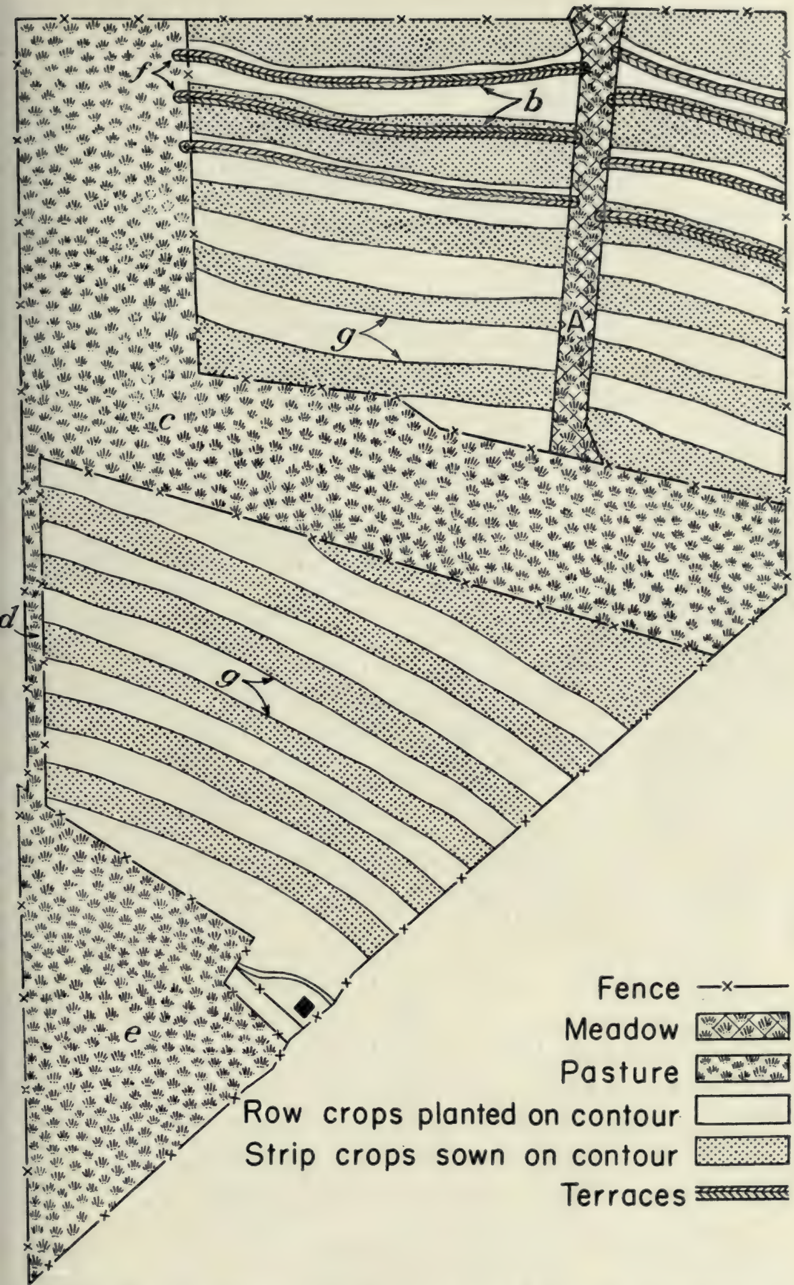

Gully
Pasture
Crops sown broadcast
Row crops not on contour

FIGURE 27.—*Diagram of a farm showing field arrangement and land-use system before erosion-control measures were applied. The fields on this farm are large, the slopes long and gradual.*


f
b
A
g
c
d
g
e
Fence
Meadow
Pasture
Row crops planted on contour
Strip crops sown on contour
Terraces

GURE 28.—*Diagram of the farm shown in figure 27 showing field arrangement and land-use system after erosion-control measures were applied.*

The Complete Farm Program

So far in this discussion the relationship of one erosion-control practice t another has been touched on only lightly. Each practice has been describe and discussed separately. It is the purpose of this section to show how th various soil conservation measures are made to merge into a harmonious whol

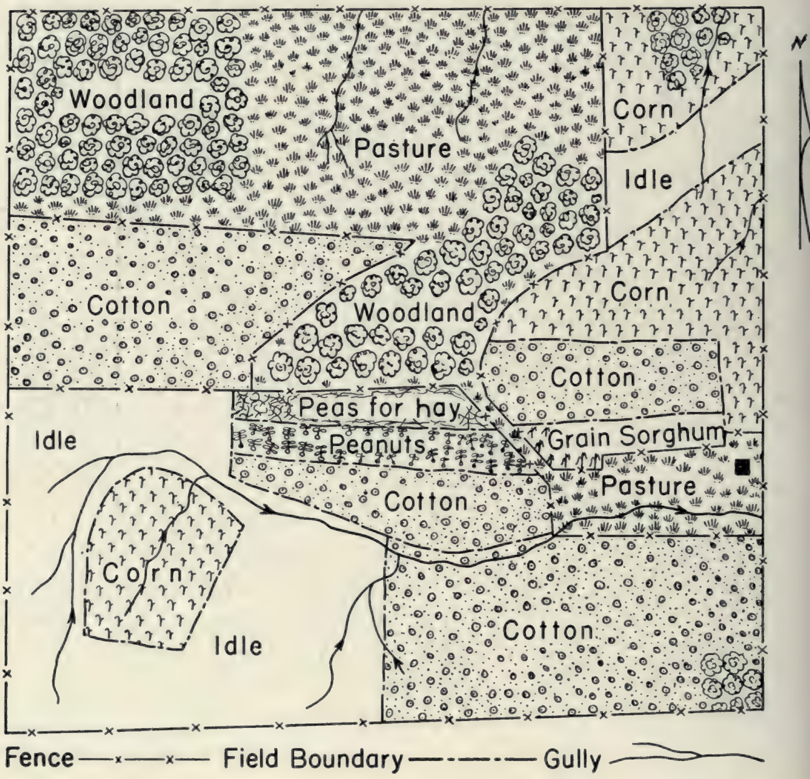
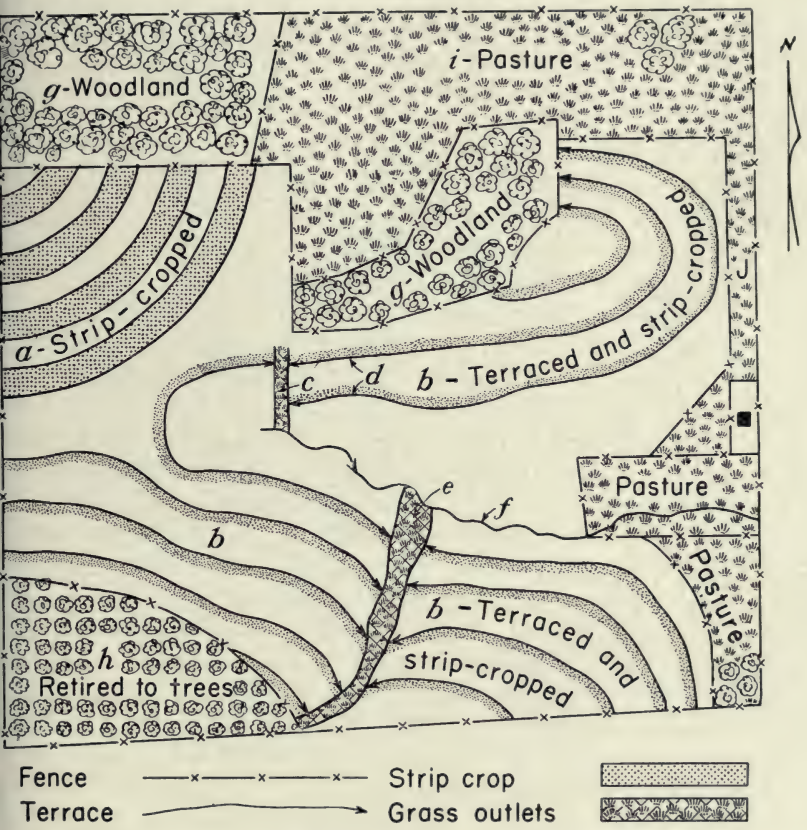

Woodland
Pasture
Corn
Idle
Cotton
Woodland
Corn
Cotton
Idle
Peas for hay
Peanuts
Grain Sorghum
Pasture
Cotton
Corn
Idle
Cotton
N
Fence
Field Boundary
Gully

FIGURE 29.—*Diagram of a farm on the upper Coastal Plain showing field arrang ment and land-use system before erosion-control measures were applied. Th fields are generally smaller, slopes generally steeper, erosion damage greater tha on the type of farm shown in figures 27 and 28.*

rm program; how one measure is made to support another, and how each field treated according to its needs and adaptabilities. Perhaps this can best be done taking actual farms for examples and diagramming them, showing the farm rangement and field plans before and after the erosion-control program was put to effect.

The farm diagrammed in figures 27 and 28 is located near Gatesville, Tex., on e Grand Prairie. The farm is representative of its section.. Fields are large, d slopes are long and gradual. In a general way the plan employed on this rm is like those employed on other farms where slopes are long, moderate in ade, not seriously gullied and the fields retain much of their topsoil. Income om this representative farm is derived from the sale of cash crops and livestock.

As shown in figure 27, no erosion-control practices were employed before the rm plan was changed. There were no terraces on the farm, rows ran down-


N
g-Woodland
i-Pasture
g-Woodland
a-Strip-cropped
b - Terraced and strip-cropped
c
d
e
f
J
b
Pasture
Pasture
b -Terraced and strip-cropped
h
Retired to trees
Fence
Terrace
Strip crop
Grass outlets

GURE 30.—*Diagram of the farm shown in figure 29 after erosion-control measures were applied, showing revisions in field arrangement and land use.*

hill, and no established crop-rotation scheme was being used. Figure 28 show the farm arrangement after erosion-control measures were applied. All of th gullies (shown by winding lines in fig. 27) were plowed in and sodded. On gullied area was seeded to grasses after being sodded to form a meadow strip (a This meadow strip takes water discharged from the terraces (b) constructe across the upper end of the long north slope where the field receives water fro a farm lying on higher land. Erosion here was farthest advanced. The gullie area to the west and the gullied area through the middle of the farm were co verted into pasture (c), connected by a fenced lane (d) to the original pasture (by the homestead at the south. Water from the west half of the three lon terraces is discharged into the new pasture; water from the east half of the lon terraces and the four shorter terraces on the side of the field to the east is di charged into the meadow strip (the longer terraces were graded to drain in bot directions from a center point). The ends of the terraces were sodded (f Instead of growing row crops in one field and close-growing feed crops in th other, both classes of crops are grown in each field, in strip-crop arrangement (g Rows were turned so that cultivation follows the contour of the land. A def nite crop-rotation system was established by following a row crop with a clos growing crop.

The second pair of diagrams (figs. 29 and 30) represents a farm on the uppe Coastal Plain where the fields are small, slopes generally steeper, erosion damag usually greater, and a wider variety of erosion-control measures must be used

As shown in figure 29, this farm consisted of a number of small irregularl shaped fields, some of them only 3 or 4 acres in size. Gullies had appeared in th fields, destroying about 12 acres of land. A survey revealed that from one-fourt to all of the topsoil had washed from 79 percent of the farm. About 65 acre remained in cultivation; 40 acres were woodland, pasture, and idle land. N definite crop rotation was being followed.

Figure 30 shows the farm after the fields had been rearranged and erosion control measures applied. Only one field (*a*) was sufficiently moderate in slop and regular in its surface features and retained enough topsoil not to requir terraces. This field was strip-cropped. All other cultivated fields were ter raced and strip-cropped. Gullies in all fields were plowed in, and a shor sodded terrace outlet channel (*c*) was constructed to care for water from one en of the terraces (*d*). A gully (*e*) was plowed in and seeded to meadow grasse to carry water from the new terraces to the natural drainage (*f*) which passe through the middle of the farm. Livestock was fenced out of the woodlands (*g*) Water from one end of the terraces (*d*) was turned into the protected woods The eroded, steeper slope (*h*), mostly idle land, was planted to trees. Some o the cultivated land, about 10 acres in all, was made into pasture (*i*) by sodding and seeding. All of the pasture land was contour-ridged. The pasture at the northern side of the farm was connected to the pasture by the homestead by a fenced lane (*j*). All of the rows follow the contour, and a definite crop rotatio has been established.

Recommendations By Regions

Throughout the South there is wide variation in agricultural conditions. Soils iffer widely not only in fertility but in susceptibility to erosion. There is a vide variety of conditions of rainfall and climate, a wide range in vegetation. ome sections are drained by an intricate network of small streams, and fields re therefore small and the slopes short and, in many instances, steep. In other ections there are fewer streams, and the slopes are long and gentle and the elds large. In some localities farmers use small equipment, elsewhere large- cale power machinery. Some are old farming sections, badly washed; in others ultivation is relatively new, and the problems of erosion are only beginning o cause concern. Then there are the vast alluvial bottoms along the trunk treams where the erosion problem is slight. Obviously under such diverse con- itions no standard set of erosion-control practices may be applied universally, nd erosion-control practices therefore must be adjusted to each region, just as a uit of ready-made clothes must be altered and tailored to fit the purchaser.

The parts of seven States of which this bulletin treats may be divided into a umber of so-called erosion-problem areas (fig. 31). Within these areas, or agri- ultural regions, conditions are fairly uniform, and recommendations as to crop otations, arrangement of strip crops, type of terrace structures, treatment ac- orded severely eroded cropland and pastures, and other erosion-control measures re sufficiently similar to admit of descriptions less general in nature than it has een possible to give heretofore in this bulletin. Methods are described for the ulf Coastal Plain, the blacklands of Alabama and Mississippi, the Mississippi oessial region, the upland Coastal Plain, the blacklands of Texas, the Grand rairie, the West Cross Timbers of Texas, and southern Oklahoma. It is sug- ested that you turn first to the region in which your farm is located.

Gulf Coastal Plain

That part of the Coastal Plain of which this section treats (fig. 31) is gently olling to rolling. Along some of the streams there are narrow overflow bottoms nd wide second bottoms, or terraces, which slope very gently. Along many treams there is little first- or second-bottom land.

Cotton and corn are the principal crops grown. Oats, the leading small grain, re widely used as a nurse crop with lespedeza. Soils are generally deficient in organic matter. The seasons of severe erosion are in the summer and winter, when many of the rains come as quick downpours. In other seasons rains are usually less violent and less damaging.

In much of the area terracing and contour cultivation are commonly practiced, but in some sections these practices are not yet employed. Where terraces have been used they have held better than in most areas of the Cotton Belt, as the soils for the most part are sandy and well drained and take up water readily.

On cultivated slopes up to 2 percent, in project areas, contour cultivation and a systematic crop rotation to maintain organic matter and fertility have been found sufficient to control erosion. In the rare instances where very moderate slopes are sheet-washing badly it is necessary also to use strips of close-growing crops to check effectively the rate of erosion, and to terrace where small gullies have appeared in the fields.

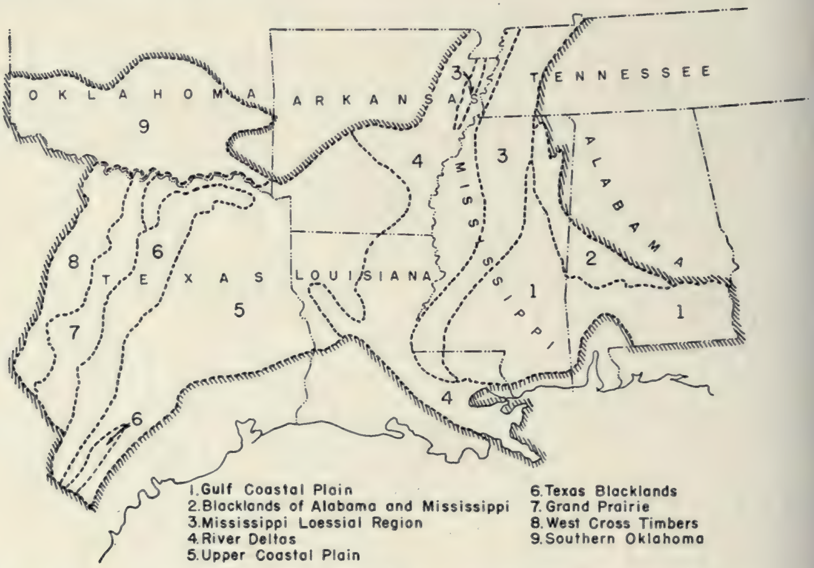

OKLAHOMA
ARKANSAS
TENNESSEE
ALABAMA
MISSISSIPPI
LOUISIANA
TEXAS
9
4
3
3
8
6
2
5
7
1
1
4
6
1. Gulf Coastal Plain
2. Blacklands of Alabama and Mississippi
3. Mississippi Loessial Region
4. River Deltas
5. Upper Coastal Plain
6. Texas Blacklands
7. Grand Prairie
8. West Cross Timbers
9. Southern Oklahoma

Figure 31.—*Map showing the principal erosion-problem areas in that part of the Cotton Belt for which detailed erosion-control measures are discussed in this bulletin.*

Slopes from 2 to 5 percent are terraced or strip-cropped or terraced and strip-cropped, and crops are grown in rotation. Strip crops are used without terraces on slopes of 2 to 5 percent only on land where there has been little erosion and where the conformation of the slope is uniform. But in many cases, especially on farms where most fields slope more than 4 or 5 percent, these moderate slopes are not strip-cropped; they are protected by contour cultivation, terraces, and rotation of crops, and the acreage that can be devoted to close-growing crops in strips is reserved for the steeper and more erodible slopes. On farms where restock provides one of the principal sources of farm income, and therefore ere is need for a larger proportion of close-growing crops for feed, the moderate opes of 2 to 5 percent are also strip-cropped.

Cultivated slopes from 5 to 8 percent are strip cropped and terraced and crops e grown in rotation to give the full protection these steeper slopes require. henever possible, slopes of above 8 percent are planted to close-growing crops d not to row crops. Where such slopes cannot be retired from cultivation ey are terraced and kept under close-growing cover as much of the time as ssible. On most farms, however, slopes of above 8 percent are made into sture or permanent meadow or are planted to trees and shrubs.

The crop rotations used in project areas in this region are quite varied. However, one of three systems is used in the majority of fields. In the section represented by the Canton, Miss. project, the hill land is adapted to cotton and the ttom land to corn. The rotation used, therefore, is either cotton or corn llowed by a winter legume. The corn is often grown in alternate rows with wpeas or velvetbeans. Vetch and Austrian Winter peas are the principal ver crops. Austrian Winter peas are preferred for a winter cover crop on nd to be planted to cotton because they are ready to be turned under in the ring for green manure about 2 weeks earlier than vetch, in time to decompose rtially before cotton-planting time. Where corn and cotton are grown in the me fields, crops usually are planted either in a 2-year or a 3-year rotation. The year rotation is cotton, followed by vetch or winter peas, followed by corn terplanted with cowpeas or velvetbeans in alternate rows with the corn. The year rotation is oats or oats with vetch, followed by cowpeas; cotton, followed a winter cover crop; and corn. In this rotation the oats are planted in strips d occupy a third of the land. The cowpeas or beans are not harvested but e turned under to improve the soil. When it is not possible to follow all of e cotton with a winter cover crop, the cover crop is planted on land that is to in late corn the following year. On most farms there are fields in 2-year rotion and fields in 3-year rotation. The 3-year rotation is necessary to provide fficient feed for livestock.

The placement of the close-growing crops in strip-cropped fields is changed om year to year. In effect this brings into play a longer rotation which goes ong with the shorter rotation. The crops used in erosion-control strips are ainly oats followed by lespedeza. The lespedeza stands 2 years. After the spedeza is turned under, the land goes back into row crops. Since on most rms only about 20 percent of the land can be devoted economically to lespeza, 10 years are required to complete the rotation cycle. Other close-growing ops used in strips are sorghum with cowpeas, crotalaria, and soybeans in close ws.

Strips are adjusted to the terraces on terraced land. Strips range in width om not less than 20 feet to 80 feet or more, although 40 to 50 feet is the width ost generally recommended.

Some permanent strips are used. These generally are confined to the steepe parts of slopes. In parts of the Coastal Plain many gradual slopes break sharpl and then lower down again assume a gradual grade. The breaks are generall short, but owing to their steepness they wash and gully badly when in ro crops. In project areas these are seeded down permanently to lespedeza o planted to kudzu. Many entire fields on steeper slopes are planted to kudz (fig. 32) or lespedeza.

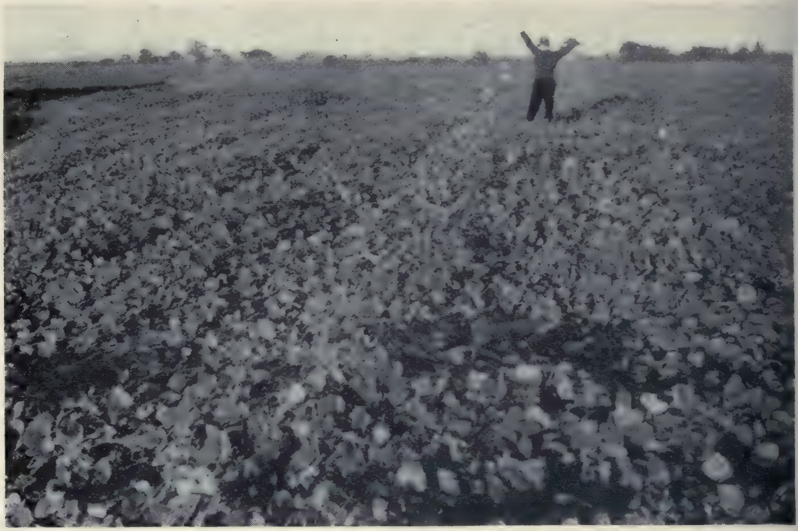


FIGURE 32.—*Kudzu, a legume, is planted on washed and gullied slopes, or slope too steep for row crops, in project areas. Its greatest success as a plant fo erosion control is in the cotton States east of the Mississippi River. Kudz makes excellent forage.*

Terraces are made 18 to 24 feet broad and raised to a settled height of abou 18 inches. Terraces are built either with large power equipment or, as at th Laurel, Miss., project, with long-wing horse-drawn terracing plows. With th latter equipment about 2 years is required to raise the terraces to the desire height.

Where the soil takes up water readily, as the deeper sandy soils do, there i little run-off from terrace ends except during torrential rains in the summer. I these circumstances it is not difficult to dispose of terrace water safety. Terrac water is turned into pastures, meadows, or woods. When such outlets are no available outlet channels sodded with Bermuda or carpet grass are provided.

About a fifth of the land, roughly, in coastal plain project areas, is retire permanently from cultivation, not including new land in meadow. Most o this land is converted into pasture, although forest and wildlife plantings ar ade on a part of it. Both carpet and Bermuda grass are used for the pasture se, with perhaps greater use of carpet grass than elsewhere in the South. ch plants as Dallis grass, lespedeza, and hop and white clover are introduced ter. All pastures, new and old, are fertilized and limed, and contour ridged furrowed. The distance between ridges is 10 to 25 feet; that between furrows to 7 feet. The spacing is determined by the degree of erosion, the steepness the slope, and the soil type. On steeper slopes, moderately eroded land, and odible soil types the closer spacings are used. After they are seeded, gullied aces in pastures are mulched with forest litter, pine needles, cane pomace, or scarded hay.

Several tree species are planted, principally loblolly, shortleaf, slash, and ngleaf pines, and black locust.

Plantings for wildlife are usually restricted to odd corners of farms and gullied eas. Privet hedge, bush lespedeza, coralberry, wild plum, Himalaya berry, d shrub dogwood are planted in the gullied areas, and mixtures of millet, mmon lespedeza, and *Lespedeza sericea* are sown in the odd corners.

Blacklands of Alabama and Mississippi

The black prairie begins in south-central Alabama and extends northwest, ossing into Mississippi near the center of the eastern boundary of that State d extending north almost to Tennessee. The first project area established by e Soil Conservation Service to serve the blacklands was centrally located at est Point, Miss., about 18 miles from the Alabama State line. Recently, other has been located near Marion, Ala.

The soils in the blacklands are heavy, lacking in humus, poorly drained, and ghly susceptible to sheet washing. They take up water slowly, and much is st as run-off. Soil losses have been greater in the blacklands than is realized. survey of land conditions revealed that from a half to three-fourths of the psoil had been removed from many fields by rain wash. The soils originally ere dark in color, but now in many localities erosion has removed the surface yer, revealing a light-colored subsoil layer. However, throughout the area ere is general lack of appreciation of the damage caused by unrestrained run-off hich accounts for the infrequency of planned erosion-control measures. Farms run their rows downhill because they desire quick drainage. Contour farming d terracing are rarely practiced. A grass-cotton-corn rotation is used, owing, wever, to the peculiar growth habits of Johnson grass, now the natural vegetion of the blacklands. Johnson grass in cotton is an exceedingly troublesome eed; after 3 or 4 years in cultivation, cottonfields must be turned back to grass. it after 2 or 3 years in meadow or pasture Johnson grass roots come to the rface, and the field may again be planted to cotton or corn. An analysis of e agriculture within the project area showed that cotton occupied the land years in 10, Johnson grass 3 years in 10, and corn once in about 10 years.

Farmers cooperating with the Service are introducing a definite crop rotatio They are using a 5-year rotation of 2 years of cotton, 2 years of Johnson gras for hay, and 1 year of corn. A winter cover and green-manure crop is plante sometime during the rotation, usually on land to be in corn the following yea Vetch and Austrian Winter peas do well.

Sloping fields are contour-farmed and strip-cropped. Slopes above 3 percent i grade also are terraced, although of necessity terraces are constructed on slop of lesser grade where soil losses have been heavy. The higher parts of lon slopes of lesser grade also are terraced.

Control strips are planted to feed and soil-improving crops: sorghum and cow peas mixed, some cowpeas and soybeans alone, crotalaria, alfalfa, lespedeza, an sweetclover. Oats are planted in strips on the light-textured soils.

Johnson grass is not a good erosion-control plant under blackland condition It is coarse growing, and water riffles around and erodes the soil between t individual plants. Therefore even when a field is in hay the field is stri cropped. Strips of alfalfa are planted on heavy Houston soils and well-draine Trinity soils, where this crop grows well; and on soils where they are adapte lespedeza and sweetclover are used. Alfalfa strips are expected to stand 5 year Strips of lespedeza and sweetclover stand for 2 years.

The width of the strips of close-growing crops is not less than 30 feet. T strips of row crops are 60 to 75 feet wide, the lesser width is applied to the mo erodible soils and slopes.

The ease with which meadow becomes established, the moderate grade of t slopes, and general topography suggest the use of meadows as the most econom cal disposal system for terrace water. Johnson grass comes in quickly a naturally, but since this grass alone does not afford sufficient protection, t meadow is strengthened by the addition of other plants. When quick grow is wanted for immediate protection in outlet meadows, common lespede Sudan grass, Dallis grass, black medic, or hop or white clover may be sown, t selection depending on the soil type.

Terrace-outlet channels are constructed on slopes above 4 percent. Bermu grass is used in the channels. No satisfactory substitute has been found.

Probably slopes of more than 7 percent in the black prairie cannot be profitab cultivated for long. Such slopes at West Point, of which there are few, a taken out of cultivation, fertilized, and made into pasture or meadow. Mu land of less than 7-percent slope is made into pasture. Whether a field is co verted to pasture depends more on soil type and degree of erosion than on slop The pastures consist of a Johnson grass base with clovers, Dallis grass, a lespedeza added. Pasture land that is not to be returned to cultivation is contou ridged rather than terraced. Temporary pastures are terraced rather th contour-ridged. The ridges are spaced about 10 feet apart. The Nichols ty of terrace is used on meadowland and temporary pasture, because mowers pa er this structure more easily than over the Mangum-type terrace and there is s interference with other machinery operations.

Both the modified Mangum and Nichols terraces are built in cultivated fields. l terraces are built with power machinery. Light equipment cannot operate ciently in the black prairie. The soils are heavy and sticky, and the subsoils, ecially, tend to roll.

Mississippi Loessial Area

East of the lower Mississippi flood plain there is a strip of land about 50 miles de that, according to most geologists, was covered by a deposit of wind-blown l during some remote period in the past. This deposit of loessial soil material ends from the mouth of the Ohio River to the lowlands along the Gulf of exico. The bluffs along the Mississippi, where the deposit of wind-blown l is deepest, form its western boundary. East from the bluffs the soil deposit dually grows thinner until it fades to a trace.

Before the war between the States almost all of the loessial region was culti- ted. The soil was highly prized for cotton. But wind-blown soil material is ghly erodible. It washes and gullies easily. In cotton, the humus-filled top- l washed away, and yields declined. The land then dropped out of cultiva- n until the humus content was built up by natural vegetation, when it was ought back into cultivation for a few years. This is the old farming system of ltivation and rest, which was tried and failed in the eastern Appalachian and edmont country. In the Soil Conservation Service project area at Port Gibson, iss., fields have been in and out of cultivation three and four times in the last years. Up to 3 feet of soil has been lost during this brief period.

Little effort has been made in the past in the loessial area to hold the soil. w fields have been terraced or contour-farmed; winter cover crops have been own only a few years and only on a small part of the land.

When care is taken to preserve and replenish the supply of organic material, essial soil responds unusually well to a vegetative program of erosion control. ne loessial soil of the Mississippi Valley is productive and produces abundant getation quickly. Where winter cover crops have been grown the results ve been uniformly good. Their strong growth provides excellent vegetative ver during the erosive periods in the winter and early spring. And, turned der, the organic matter and nitrogen provided by the legumes maintains a ghly productive soil condition. On the Port Gibson project, winter cover ops, principally vetch and some Austrian Winter peas, are grown on a high rcentage of the cultivated land.

All sloping land irregular in conformation owing to gullying, and all land oping above 5 percent that is to remain in cultivation, is terraced on the project ea at Port Gibson. Both the Mangum and Nichols types of terraces are built. he Mangum terraces are used on slopes up to 6 percent in grade, the Nichols type terraces on slopes above 6 percent. Terraces are made somewhat smalle than standard specifications require, for terraces having a base width of 15 t 18 feet have proved adequate in size for the smaller fields common to the loessia area. It has not been necessary to build many outlet channels at Port Gibson Usually water may be turned into woods, pasture, or meadow. In instance where no other means of disposing of terrace water could be devised, outle channels were constructed and sprig-sodded with Bermuda grass or seeded t carpet grass, hop and white clover, and lespedeza. Outlets prepared in the fal are seeded to Italian ryegrass or oats for winter protection in the first season Outlet channels sloping more than 6 percent are sodded solidly with Bermud grass.

Land sloping more than 2 percent, and all terraced land, is strip-cropped. T start the strip-cropping system a mixture of cowpeas and sorghum is planted i strips during the first summer season. This is followed by oats and lespedez the lespedeza standing for 2 years.

A minimum of one-fifth of the cultivated land is planted in close-growin crops in strips. In the Port Gibson area the average amount of land per far in close-growing strip crops is 27 percent. Strips are not less than 30 feet wid and may have a width of as much as 60 feet. On terraced land the contr strips are placed astride every second or third terrace, beginning at the uppe side of the terrace and extending over the terrace and into the terrace interv the desired distance. On steeper slopes, where terraces are spaced more closel the strips of close-growing crops are adjusted to every third terrace; on less slopes, to every second terrace.

Since the hill land is adapted to cotton production and the bottom land t corn, in much of the loessial area, the rotation employed in the interstrip sectio on uplands is cotton followed by a winter cover crop, and on the lower land corn followed by a winter cover crop. The location of the strips is moved fro terrace to terrace at the end of each 2-year period. Since only about one-fift of the land on most farms may be devoted profitably to lespedeza, under th present farming system, about 10 years must elapse before the rotation of cotto oats, and lespedeza is completed.

Slopes of from 10 to 12 percent are devoted to meadow, continuous productio of other close-growing crops, or pasture (fig. 33). Slopes of 12 percent and ove either are made into pasture or planted to trees and shrubs, depending on th need of the farm for pasture and woodland. Kudzu is grown as a meadow cro on badly eroded land and thrives.

Newly made pastures are contour-ridged or furrowed, sprig-sodded wit Bermuda grass, or seeded to carpet grass and overseeded with a pasture mixtur consisting of common lespedeza, white Dutch and hop clovers, and Dallis gras On thin land some carpet grass seed is added. Natural pastures usually contai more carpet grass than Bermuda grass. These pastures are contour-ridged o furrowed, and the disturbed areas seeded to the same mixture.

Pasture contours have proved popular with farmers at Port Gibson. They ve not only improved pasture growth but, by holding the water back, have lped to make corn growing possible on lowlands which were flooded peri-dically before an erosion-control program was effected on the upland slopes.

Hardwoods grow unusually well in the Mississippi loessial area. An oak Port Gibson attained a diameter of 30 inches in 27 years. Hardwoods are erefore planted on land retired permanently from cultivation. Red oak, hite oak, ash, poplar, and, for fencepost stock, some black locusts are the ecies used.

GURE 33.—*This badly eroding field in the loessial area of Mississippi was retired to pasture. Contour ridges were constructed in December 1936. The field was then seeded to hop and white clover, lespedeza, and Dallis grass. This picture was taken 5 months later.*

Crowley's Ridge in Arkansas

West of the Mississippi River in east-central Arkansas there is a strip of essial soil known as Crowley's Ridge. The ridge is deeply dissected by many vines, and the fields consequently are small. They comprise only a few acres. is not practical to terrace these small fields. They lie high above a stable ade, and water concentrated by terraces cannot be safely directed away ithout too great expense.

Only the very gently sloping land, the level fields, and some of the hilltops the ridge are planted to row crops. On the project area near Forrest City e cultivated hilltops and the so-called upland bottoms are surrounded by rder strips and strip-cropped. The edges of fields which break into a ravine e bordered with Bermuda sod and lespedeza.

The slopes and hilltops in the project area are used for pasture, permaner lespedeza meadow, or for woods. Hilltops are cultivated only on farms on whic there are few upland bottoms. All pastures are contour-ridged or furrowe sodded with Bermuda grass sod where the cover is sparse, overseeded, fertilize and limed. Here, as in the loessial uplands of Mississippi, the more valuab kinds of hardwood trees grow rapidly, and woodland management offers a opportunity to secure permanent income from extensive areas of steeply slopir land.

The streams from the ridge drain to the west and cut through broad, gent sloping second bottoms normally above overflow. The soils on these secor bottoms are similar in character to those on the ridge, although here soils wit compact and tight subsoils are much more extensive than on the ridge. The wash severely from the more sloping lands unless control measures are applie Cotton and corn and a very little lespedeza are the principal crops grow Farmers buy nearly all their hay.

Second-bottom land in the project area is strip-cropped. Strips planted in t fall are wheat, rye, or oats. In the spring the strips are overseeded with lesp deza. The lespedeza stands for 3 or 4 years. Then the strips are relocate Sorghum and peas or Sudan grass are used in strips started in the summer. Th strip-cropping plan is to alternate 25 feet of close-growing crop with 75 feet row crop. Corn is interplanted with soybeans or cowpeas.

Upper Coastal Plain

The upper Coastal Plain is an area of sandy soils in eastern Texas, nort western Louisiana, southeastern Oklahoma, and southern Arkansas. It is o of the older farming areas of the South, settled by pioneers of farming stoc The soil was never rich, even in the days before cash-crop farming. The organ layer under the hardwood and pine forests was scarcely 3 inches deep. U doubtedly much of the forest land should never have been cleared for cultivatio and much of the land once cleared is no longer cultivated and should be returne to forest. But there are sizable tracts on the upper Coastal Plain where the sc is good and, when wisely handled, productive. Fields which retain some of the topsoil respond readily to good soil-management practices. Turning under tw or three crops of cowpeas or winter legumes for green manure, for exampl invariably improves the productiveness of the soil.

Cotton farming, which displaced the pioneer self-sufficient agriculture, quick exhausted or stripped the organic layer of soil from the rolling lands, and f years cotton farming has been an unprofitable single enterprise. Althou cotton promises to remain the principal cash crop, it is recognized that a redu tion in the acreage of this crop must occur on most farms before a farmer ca expect, by a system of crop rotation and farm reorganization, to build up ar maintain the productiveness of his soil and reduce soil wastage.

The more successful farmers in the area have diversified their farming. Many now produce all of the feedstuff required by their work stock and a large part of the family supplies, which formerly were purchased with cash procured from the sale of cotton. However, these men are a minority. An agricultural extension agent in a northwestern Louisiana parish, surveying the local feedstuffs situation n March 1937, found that not more than 60 farmers in his parish had enough feed on hand to carry their work stock through the planting season. The cash outlay in this parish for feed totals more than $200,000 a year. A recent economc study of farm organization made by the Texas Agricultural Experiment Station for the upland Coastal Plain of that State reveals the benefits of diversification. Different combinations of cotton with tomatoes, sweetpotatoes, watermelons and peas, and dairying, yielded more net farm income than straight-cotton farming.

On most farms of the upper Coastal Plain it is necessary to carry out a complete reorganization of the cropping system in order to accomplish effective erosion control, in addition to making full use of such mechanical measures as terracing, contour farming, and contour ridging or furrowing of pastures. Less cotton and corn, but more of the close-growing feed crops are grown on farms so reorganized.

In project areas small grain has displaced part of the cotton and supplemented corn as a feed crop. Since average corn yields in many counties on the upper Coastal Plain do not exceed 10 bushels an acre, the small grains have produced, acre for acre, more feed than corn. Whole fields have been diverted from the production of row crops to meadowland and pasture. The effect of this shift n field use, together with a program of strip cropping, has been to provide, for the first time in many years, sufficient feed at least to carry work stock through the planting season. In many instances there has been a surplus of feed produced over the needs of the work stock. This surplus has not always been sold. A number of farmers have bought dairy cows, and they find that the monthly check received for a few cans of milk set on the road in the morning meets the operating expenses of the farm. Money from the sale of cotton is their profit. Several project areas, incidentally, are being served by new milk plants built since the local feed situation improved.

The eroded condition of most slopes and surface irregularities are such, on the upper Coastal Plain, that terracing is employed as a basic erosion-control measure on most upland fields. There are some slopes under 2- or 3-percent grade and of even conformation which do not require terraces; but these are relatively few. The modified Mangum and Nichols terraces are used. Terraces, in project areas, are constructed and spaced according to standard specifications for variable-grade structures, although in some sections where fields are small, as around Monticello, Ark., smaller terraces have proved dependable on fields of 4 or 5 acres. Before terraces are made, washes and gullies are plowed in to assure less concentration of water and clogging of the channels of terraces.

Elaborate plans for disposing of terrace water are seldom necessary. Even in sections most developed agriculturally less than half the land is cultivated. Under these conditions terrace water usually may be directed into a woods, a pasture, or a meadow. When it is necessary to provide outlet channels, thes are strip-sodded when the grade is not more than about 4 percent and sodde solidly when the slope is steeper. Bermuda is the only dependable grass to us in most sections, although in localities where carpet grass grows well this gras has proved satisfactory.

All sloping fields, in project areas, whether terraced or not, are strip-cropped The strips of close-growing crops occupy from a fourth to half of the field area The proportion of the field devoted to close-growing crops is greater on th steeper slopes and in fields which have lost a good part of their topsoil.

Close-growing crops planted in summer strips are Sudan grass, redtop sorghum or hegari, usually mixed with cowpeas. For fall and winter protection oats o rye or sometimes barley or wheat, often in combination with vetch, are grow in strips on soils suitable for small grains. Where the soil type is unsuited t small grains, the stubble from the summer strips is left standing to aid in erosio control during the winter season.

When strips are used with terraces, one or a combination of the methods show in figures 14 to 19 are used. Newly made terraces are always protected durin their first year by a close-growing crop, as shown in figure 14.

Lacking both mineral fertility and organic matter, soils of the upper Coasta Plain generally yield poorly. It is essential, therefore, in an erosion-contro program depending mainly on vegetation, to improve soil fertility so that vegetation will grow strongly. As a first step a systematic rotation of crops i introduced. The crops are grown in such sequence that the soil is protecte by a vegetative cover as much of the time as possible. A legume appears som time during the rotation and is turned under for green manure, to supply nitroge as well as organic matter.

Farmers who depend on livestock for a part of their cash income, and no wholly on cotton, are able to employ longer rotations of a kind more satisfyin for soil-improvement purposes. They can use rotations that cover 3 or 4 years whereas farmers who depend on crops for their sole source of cash income can at best, use only a 2-year rotation. Table 4 lists some of the crop-rotation systems being employed in the project areas of the Soil Conservation Service on th upper Coastal Plain.

Badly gullied fields, fields sloping more than 8 percent, and fields of less grad from which the greater part of the topsoil has been removed by erosion are converted into pastures or woods. Some fields are seeded to grasses for permanen meadow. In some sections bottom lands have been used for pasture and th uplands for the production of field crops. When danger from overflow is no great, part of the lowland pasture is plowed and planted to field crops and th sloping, eroding fields are planted to grass to offset the loss of lowland pasturage In the project area at Nacogdoches, Tex., the land-use program on a number o rms has been reversed by this procedure. A combination of lowland and pland pastures provides a longer grazing season and better-quality pasturage.

TABLE 4.—*Crop rotations employed in erosion-control programs on farms on the upper Coastal Plain*

First year	Second year	Third year	Fourth year
otton or other cash crop followed by oats or oats and vetch.	Corn in 6-foot rows with cowpeas or velvetbeans planted in the middle.		
otton or other cash crop followed by oats or oats and vetch.	½ corn and ½ sorghum	Cowpeas	
otton or other cash crop followed by oats or oats and vetch.	Corn in 6-foot rows with cowpeas or velvetbeans planted in the middle.	½ Sudan grass and ½ sorghum.	Cowpeas.

Pastures are established on suitable soil types by sodding with Bermuda grass d overseeding, principally, with hop and white clovers, bur-clovers, black edic, common lespedeza, and Dallis grass, according to local adaptability. me of the lowland areas are sodded with carpet grass and overseeded. It is cessary to lime and fertilize most fields before pastures can be made. The nounts used depend on local requirements. Most of these soils are deficient available phosphorus and require an application of some phosphatic fertilizer insure success.

Contour ridges or furrows are constructed on many sloping pasture fields to tain moisture and lessen the rate of erosion until vegetation is dense enough control soil washing. To establish and maintain pastures in good condition, stures are mowed three or four times during the first season or two and less ten in later years, to control weed and shrub growth.

In Arkansas the practice of sodding in strips has gained favor in areas where mmon lespedeza does well. Sodded strips 25 to 50 feet wide alternate with rips of equal width sown to common lespedeza. The strips are laid out on the ntour. Eventually the Bermuda grass will spread across the strip of lespedeza. he strips of Bermuda grass meanwhile hold soil movement in check. The dvantage of this method is its lesser cost.

Many slopes are retired to trees, particularly where there are fine sandy soils, hich are not suitable for pasture. Plantings are mainly pines and locust. here is a general need for fence posts, and many of the smaller fields are planted black locusts to meet this need. The pine plantings are interplanted with rubs and hardwood trees which provide food and cover for wildlife.

The Blacklands of Texas

Seventy-five years ago the blacklands of Texas were prairie. Most of the ol prairie sod was turned less than 50 years ago. Little land has been farmed mor than 65 years.

The soils of the blacklands are highly erodible. They sheet-wash easily sinc the surface soils are naturally loose and granular and rest on heavy clay layers Up to a certain point the soils absorb water fairly readily. As they become dry they shrink and crack, and gullies often start from the crevices. As they becom wet, the soils swell and seal, and water runs rapidly over the surface. Becaus of the topography of the area and the character of the soil, sheet erosion is fa more serious in the blacklands than is gully erosion. Few farmers, the majorit of whom are tenants, have made much effort to control soil washing. Indee many of them are unaware of the extent of damage caused by erosion, althoug here and there telltale outcroppings of the underlying chalk and marl reveal tha all of the topsoil has washed away. A survey of land conditions in blacklan project and camp areas revealed that many fields had lost from 25 percent to a much as 75 percent of their topsoil. The survey, involving 280,000 acres, revealed that 12.5 percent of the land exhibited no erosion damage; 46 percent o the land had lost not more than one-fourth of the original topsoil; 26.8 percent ha lost from a fourth to three-fourths of the topsoil; 12 percent had lost more tha three-fourths of the topsoil and exhibited numerous gullies; and 2.7 percent of th land had lost all of its topsoil, and gullies had cut through the parent soil materia

Little of the blacklands is terraced; nearly all rows run downhill; for the mos part, crops of the erosion-permitting kind are grown, and continuous croppin rather than rotation of crops is the rule.

Erosion-control treatments in the blacklands are determined largely by th degree of slope in the field and the severity of erosion. The various soil types except in their shallow phases, are managed in very similar manner. There i little land that will not benefit from some protective practices. In project area only land that slopes not more than 0.5 percent, which to the eye appears practically level, is neither strip-cropped nor terraced. Slopes of more than 0.5 percent are strip-cropped. On slopes of up to 3-percent grade, terraces are use with strips where the length of the slope is greater than 1,000 feet. On slopes o from 3- to 7-percent grade, terraces are used with strips where the length of slop is greater than 700 feet. However, all fields badly infected with root rot ar terraced even when strip-cropped. Moderate slopes, even though short, ar terraced if gullies have appeared in the field, or if half of the topsoil has been lost Slopes of from 7 to 10 percent, if they are not to be retired to meadow or pasture are kept under a continuous cover of oats, wheat, or barley over winter, and th stubble is left standing for summer protection; or, half the slope is kept in winte cover followed by stubble and half under a summer cover of Sudan grass o ɔrghum, the winter and summer crops being planted in alternate strips 45 to 60 :et wide.

Because it is not a natural tree country, most land that is retired from row crops, wing to steepness of slope and eroded condition, either is kept permanently in ɔwed or drilled crops, or meadow or is made into pasture. It is practically npossible in the blacklands to grow row crops on slopes of more than 7 percent ıd effectively control erosion.

Terraces are of the modified Mangum type, broad enough to accommodate ıultiple-row machinery. The first 400 feet of terrace length is made level; after ıat the terrace is given grade which is increased at the end of each 400 feet of ngth. Terraces do not ordinarily exceed 2,000 feet in length. Terrace water turned, whenever possible, onto meadows or pasture land. However, owing ɔ the large proportion of cultivated land in the blacklands, it is necessary more equently than elsewhere in the Cotton Belt to build outlet channels to carry :rrace water to a stabilized grade. Bermuda grass and buffalo grass are used in ıtlet channels. Sometimes Bermuda grass is sodded in the bottoms and buffalo :ass on the sides of the channel.

Infections of cotton root rot in fields greatly complicate the strip-cropping rogram in the blacklands. Root rot attacks all legumes as well as cotton. Only ıe grains and grasses are free from the ravages of this disease. Wherever root ɔt is prevalent the choice of crops used for control strips is limited to oats, heat, barley, Sudan grass, the sorghums, and the meadow grasses. Hubam weetclover, a recent introduction into the blacklands, is the most promising gume tried thus far in areas infected with root rot. When seeded in the fall : early spring it provides protection for the soil during the period of erosive ɔring rains. Oats is the most popular winter strip crop, especially in the northːn half of the area. Toward the south oats do not always produce a grain crop ıd are harvested for hay when grown in strips. Many farmers in the project :ea at Lockhart, in the southern part of the blacklands, are substituting Hubam weetclover for oats for winter control strips. Alfalfa and little bluestem (fig. 4) are planted in strips which are to stand for several years. The use of alfalfa restricted to fields not infected with root rot disease. Little bluestem, which as one of the grasses prominent in the native cover, is popular for semipermaent strips on blackland project areas. Other grasses used for this purpose are ig bluestem and, in a limited way, Indian grass.

The spacing of strips with respect to terraces is shown in figures 14 to 19.

Rotations are applied within the field on a strip-cropped farm. Fields, as ıch, are not rotated. Strips of row crops are planted between strips of closerowing crops, and these strips are moved up and down the slope from year to ear to provide for a rotation of crops. A rotation, to improve the soil, should ɔntain a legume; but the prevalence of root rot complicates cropping plans. .oot rot is in its most active stage during the summer months. Its organism is :ss active during the winter and early spring months. In order to provide a

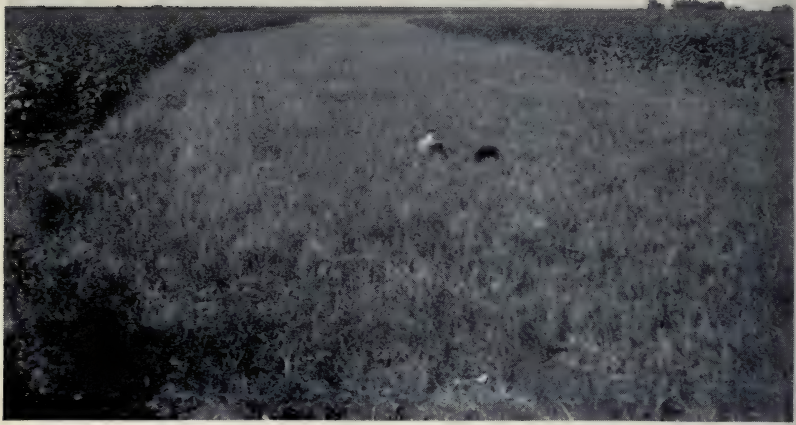


FIGURE 34.—*Meadow grasses are planted on strips that are to remain for sever years. Little bluestem is planted on contour strips in the blacklands of Texas.*

rotation for soil improvement and protection and at the same time avoid root ro damage, it is therefore necessary to resort to winter or early spring seede legumes. For this purpose, Hubam sweetclover has caught the fancy of th farmers in the project areas. Sorghums are frequently planted for green manur in place of legumes in root rot areas. Table 5 shows the rotation systems commonly used in blackland project areas.

TABLE 5.—*Rotation systems recommended for the blacklands of Texas*

First year	Second year	Third year	Fourth year
Cotton	Oats	Corn or sorghum	
Do	Corn	Hubam sweetclover	
Do	Oats	Corn or sorghum; Hubam sweetclover.	
Do	Corn or sorghum; oats	Cotton	Oats; corn or sorghum.

Established pastures sloping not more than 3 percent are mowed to contr weeds, but no other protective measures are applied unless the sod is too thin t control erosion. Then the pasture is sodded by the furrow method, buffal grass being used when available or Bermuda grass. Buffalo grass is preferred fo the higher land; Bermuda for the lower. Other pasture plants are introduced by overseeding with Dallis and rescue grass, bur-clover, black medic, an annual yellow sweetclover. Land that slopes more than 3 percent and lan newly made into pasture are contour-ridged or furrowed and mowed.

Active gullies on all pasture land are sloped and sodded; and brush interfering vith the growth of the grasses is cleared from the field. Diversion terraces are onstructed above gullied areas to carry the water away from the heads of active ullies.

The Grand Prairie of Texas

The Grand Prairie of Texas lies between the blacklands and the West Cross imbers. The 7,000,000 acres in this section are devoted to grazing, livestock rming, and field crops. Cotton at one time occupied more than half of the nd in cultivation, but in recent years the trend has been away from cotton oward increased production of feed crops and livestock, principally sheep, oats, and cattle. Owing to the growing importance of livestock in the farming ections of the Grand Prairie, it is now less difficult to adjust farming operations vith a view to erosion control than it used to be when more cotton was grown. ost farmers want more improved pasture, and increasing numbers of livestock ffer a certain outlet for the feed produced in erosion-control strips.

All cultivated fields are strip-cropped on farms cooperating with the Soil Conervation Service in the Grand Prairie. On slopes of up to 2 percent the strips f close-growing crops are 24 feet wide and alternate with 75 feet of erosion-ermitting crops. Or slopes from 2 to 5 percent the width of the strips is idened to 30 feet and the area in row crops reduced to 60 feet. A so-called 50–50 method" also is used. In this system half of the land is planted in close-rowing crops and strips and half of the land in erosion-permitting crops in strips. he width of the strips is adjusted to the degree of slope and the degree of rosion in the field. Only moderate slopes, few of more than 4-percent grade, re cultivated. Many are long. On slopes of up to 2½ percent the strips are 00 to 120 feet wide. The width of the strips on slopes of 2½ to 3½ percent is 0 to 100 feet, and on slopes of more than 3½ percent the width is 60 feet. Of e two figures given for each slope classification, the lesser one is chosen when e field is more severely eroded; the larger one when there is little erosion.

For full protection much land on the Grand Prairie must also be terraced. ince all cultivated land is strip-cropped, only those slopes are terraced which are ullied, uneven in conformation, or badly sheet washed. On terraced land the trips extend from the middle of the terrace interval, over the terrace, to the iddle of the adjacent terrace interval. With this method only half of the terrace terval is planted to a row crop each season. The other half is protected from ashing by close-growing vegetation.

Oats are the principal feed crop grown in the strips in the winter. Whenever ats cannot be seeded in the fall, spring wheat is planted, unless the spring season too wet; then the strips are seeded to millet. The oats are followed by a row rop, usually about 3 acres of cotton to 2 acres of corn, although the proportion f cotton is sometimes greater.

It is seldom necessary to build terrace-outlet channels on Grand Prairie farms. From these moderate slopes it is nearly always possible to turn terrace water into a pasture or meadow. On many farms a pasture field is extended along the edge of the cultivated field from which terrace water is to be discharged. When meadows are seeded down to a mixture containing four or five grasses the vegetation soon becomes sufficiently dense to resist the washing effect of concentrated terrace water. Little bluestem is the principal grass used. Big bluestem, Indian grass, and switchgrass are commonly added to the mixture. A little Dallis grass is included for seepy areas where the soil stays wet most of the year.

At Gatesville, the location of one of the C. C. C. camps doing soil conservation work, Hubam sweetclover (fig. 35) was introduced on one farm 7 or 8 years ago. The Hubam sweetclover reseeds itself and appears with oats. The oats are threshed. The straw, which is mixed with the volunteer sweetclover, is feed of good quality. The owner of this farm states that the productivity of his soil is constantly improving from the use of the legume and manure from his livestock. He is supplying Hubam sweetclover seed to other farmers who are seeding it with oats in erosion-control strips. Although cotton root rot is not considered so destructive as in the blacklands, in wet years the disease causes sufficient trouble to make the growing of legumes other than Hubam sweetclover unattractive. Usually the Hubam sweetclover may be harvested before root rot is noticeable.

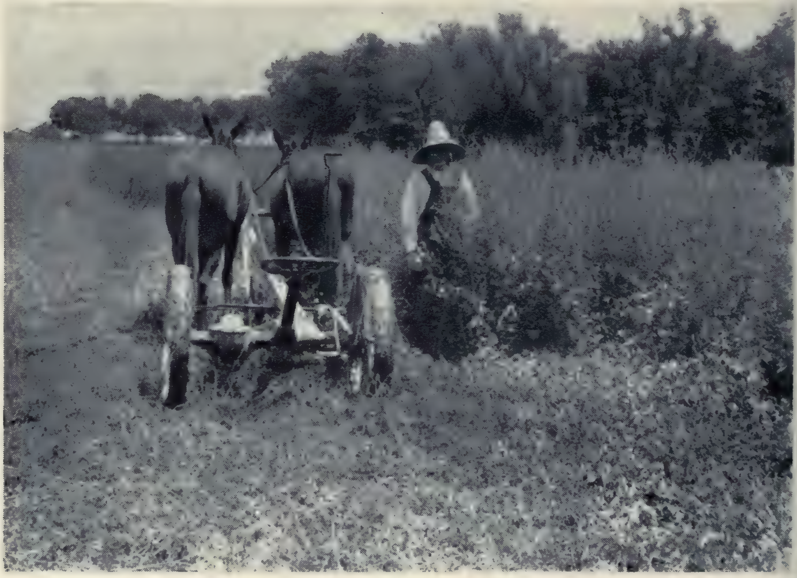


Figure 35.—Hubam sweetclover, an annual white sweetclover, is becoming popular among farmers in project and camp areas in the blackland and Grand Prairie sections of Texas.

Fields retired to pasture are sodded with Bermuda grass or buffalo grass. The buffalo grass, when available, is preferred for the higher land. The chunks of sod are dropped about 6 feet apart in furrows. Before being sodded, all fields to be made into pasture are contour-ridged. The ridges are spaced about 12 feet apart. Since most farmers keep sheep or goats, there is usually little weed trouble in established pastures. Farmers who do not have sheep or goats mow their pastures two or three times a season. Gullies are plowed in, and the banks are seeded to grasses and sodded.

The West Cross Timbers

The West Cross Timbers of Texas lie between the Grand Prairie and the Rolling Plains. They comprise some 7,000,000 acres of originally timbered land broken by small prairies. The native trees are post, live, and blackjack oaks, and other hardwoods, all of small size, except along the streams. On the prairies, needlegrass and buffalo, mesquite, and little bluestem grasses grew among scattered mesquite trees. Much of the area is too rough and rolling for crop production, and farming is restricted to the comparatively smooth, moderate slopes. These slopes were broken primarily to produce cotton, which originally occupied fully two-thirds of the cultivated fields. But in recent years, owing to declining yields and prices, the farming trend has been away from cotton toward diversified farming and livestock. Yet cotton remains the principal cash crop.

The soils in the West Cross Timbers appear to be especially susceptible to rapid erosion. When unrestrained by vegetation, run-off quickly cuts gullies that run the length of even moderate slopes in a short time. In the project area near Dublin, which is representative of the farming land in the West Cross Timbers, few fields sloping more than 5 percent have remained in cultivation (fig. 36). Farmers had, so to speak, followed their topsoil downhill, converting the steeper slopes to pasture, or, as happened in many instances, abandoned the land. A careful soil conservation survey of 80,096 acres in project and camp areas revealed that of the land still remaining in cultivation, 17 percent is bottom land and is not eroding; 50 percent has lost less than 25 percent of the original topsoil; 29 percent has lost 25 to 75 percent of the original topsoil and is gullied; and the rest is ready for retirement. The present pastures and woods that at one time were cultivated also exhibit similar conditions of erosion.

Crops are restricted, in project and camp areas in the West Cross Timbers section, to land that slopes not more than 5 percent. The control practices used are determined by the degree of slope and erosion and, to an unusual extent, by the soil type.

On land that slopes not more than 1 percent and shows no apparent erosion, control of soil washing is effected by contour farming and by including a green-manure crop in the rotation to maintain the content of organic material in the soil. But slopes of greater degree, which are losing material quantities of topsoil, require further protective measures.

Terraces are not used alone to control erosion. All terraced land is strip-cropped. Terraces have been employed for a number of years in the West Cross Timbers section, but erosion has been severe nevertheless. Unusually violent and sometimes prolonged storms occur, and unless terraces are supported by other control measures, they frequently fail. In 1936 a rainfall of 9 to 12 inches in 6 consecutive days ending with a 3-inch rain in 45 minutes broke every terrace that had not been protected by a strip of Sudan grass. The strip-cropped terraces did not fail. The terraces recommended are the broad-base, variable-grade type with a maximum channel grade of 3 inches in 100 feet toward the lower end of the terrace.

Strip crops are used on all eroding slopes. Where gullies are few and small and a fair proportion of the topsoil remains in the field, a strip-crop rotation without terraces is employed on the shorter slopes. The upper ends of slopes more than 500 feet long also are terraced. Where there are more than two or three gullies on an acre, even very moderate slopes are terraced.

Where the field does not need to be terraced, the width of the area in erosion-permitting crops on slopes of up to 2 percent is held to 75 feet. The width of the strips of close-growing crops is 24 feet, or two rounds of a 6-foot drill. The width of the strips in close-growing crops is increased to 30 feet on unterraced slopes of more than 2-percent slope, and the width of the area in erosion-permitting crops is reduced to 60 feet.

The strip-crop arrangement employed with terraces is one of the five methods shown in figures 14 to 19. Before the terraced field is strip-cropped, the small gullies are plowed in and seeded to close-growing crops.

The crops on trial in erosion-control strips for spring and summer protection are redtop sorghum, Sudan grass, hegari, cowpeas, or combinations of these crops in drills or close rows. For fall and winter protection, the crops on trial are oats, rye, barley, wheat, sweetclover, vetch or a combination of oats and sweetclover, or oats and vetch. It has not yet been determined which of these crops or combinations of crops will prove most suitable for the area.

As an aid in maintaining productivity, it is planned to rotate crops regularly so that all of the land in strips will be benefited by turning under a legume sometime during the strip rotation.

Several rotation systems, 2 or 3 years in length, are being employed in the Dublin project area. The rotation that seems adapted to most farms is cotton followed by a winter cover crop the first year and grain sorghum or corn interplanted with summer legumes followed by a winter cover crop the second year. The selection of the winter cover crop depends largely on the soil type; and weather often determines its use. The cover crops are grazed in the winter and turned under for green manure later. Corn and grain sorghums are planted in rows 6 feet apart, the summer legumes being interplanted as soon after the crop

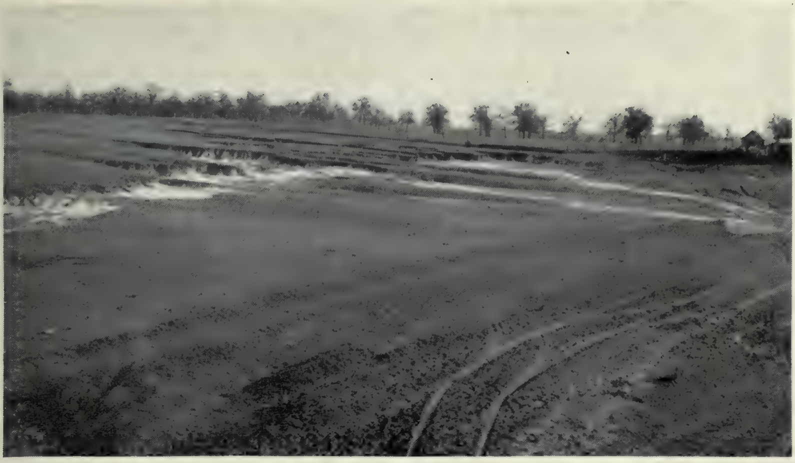


FIGURE 36.—*Soils in the West Cross Timbers section appear to be especially susceptible to erosion. They wash badly during violent rainstorms. Little land sloping more than 5 percent remains in cultivation.*

is well started as moisture conditions permit. The winter cover crops used are oats or rye alone or with annual sweetclover or vetch.

Cultivated land which has lost more than three-fourths of the topsoil, and slopes too steep or too badly gullied for further cultivation are made into pastures or, sometimes, farm woods. There is greater need for pastures. Therefore most fields of any slope that are retired from cultivation are contour-ridged or furrowed and sodded. The contour ridges are spaced about 12 feet apart.

Buffalo grass, which is native to the country, and Bermuda grass are used for pasture development in new pastures and in old pastures where the stand of grass is poor. One of the several sodding methods is employed. Before being sodded, the gullies are plowed in and seeded to vegetation that provides temporary cover quickly. When the work is done in the fall, Italian ryegrass or sweetclover is used; when the work is done in the spring, little bluestem.

When newly made pastures are overseeded with mixtures of grasses and clovers to improve the quality of the pasturage, for the most part seeds of such plants as rescue grass, Italian ryegrass, bur-clover, black medic, and Dallis grass are used. Seed is broadcast in the spring or fall or sometimes is mixed with a load of damp manure and spread, and covered lightly by a harrow, disk, or drag.

While the old pastures are being built up and new pastures are being made, supplemental feed is provided by temporary pastures—oats with sweetclover or vetch in the winter and Sudan grass with cowpeas in the summer. The stripcropping program provides further feed supplies for pasture relief. After pastures have been established and fenced, livestock is moved from one to another in rotation, to permit the pasture plants to regain strength and reseed after being grazed. Mixed grazing with cattle, sheep, and goats is practiced on many pastures in the project area, not only to make most efficient use of the available pasturage but to keep down weeds and shrubs. When pastures in this section are not grazed by sheep or goats it is necessary to mow to prevent weeds from shading and destroying the desirable pasture plants.

Southern Oklahoma

Erosion damage in Oklahoma is widespread. According to one survey 84 percent of the cultivated land suffers from some form of accelerated erosion. In southern Oklahoma, where cotton is the leading cash crop, sheet and gully erosion are noticeable on practically all sloping land. Many of the steeper slopes long since have dropped out of cultivation. In some localities little land sloping more than 6 to 8 percent is now cropped.

The predominance of row crops in the cropping systems and the character of the rainfall stand out as the principal causes of rapid erosion rates on cultivated land in Oklahoma. The rainfall in the cotton-growing sections of the State, while not frequently excessive in any season, is often intense. It is not uncommon for an inch of rain to fall in 10 minutes; and in the spring months rains of several hours duration not infrequently deliver 4 or 5 inches of water on land while it is without vegetative protection. Although many of the eroding fields in southern Oklahoma now are terraced, in other respects the farming systems employed are not greatly different from those introduced by the pioneer settlers. There are about 16 million acres in cultivation in the State; yet until recently less than half a million acres were planted annually to soil-building crops.

Growing soil-depleting and erosion-permitting crops continuously caused crop yields to decline and led to the abandonment of large acreages of land (fig. 37). A recent agronomic report states that crop yields have dropped 40 to 60 percent in central and eastern Oklahoma on land that has not known 30 harvests. Tests of samples of cultivated soils show declines of 25 to 50 percent and more in the supply of organic material and nitrogen since the land was first cultivated.

It is agreed that definite crop rotations containing soil-building and soil-holding crops must replace continuous row-crop farming if the productive life of southern Oklahoma soils is to be prolonged. In project areas the Soil Conservation Service recommends growing cotton and other row crops in regular sequence with legumes and other close-growing crops, as a first step in an erosion-control program. The usual cotton-and-corn cropping plan of southeastern Oklahoma, for example, is modified to include summer and winter legumes. Cowpeas or mung beans are planted in alternate rows, or in alternate pairs of rows, with corn; and row crops are followed by a winter legume such as vetch or a mixture of a winter legume and small grain. Some of the rotations recommended for use in project areas in southern Oklahoma are listed in table 6. In all of these rotaions soil-building and soil-holding crops appear more frequently than in the ropping systems most commonly employed. They all furnish vegetative cover or the land during a part of the rotation period.

able 6.—*Some crop rotations employed in erosion-control programs on cotton farms in Oklahoma.*

First year	Second year	Third year	Fourth year	Fifth year
otton	Vetch [1]	Cotton	Wheat, rye, Italian ryegrass, or winter oats.	Cotton.
Do	Corn or sorghum with summer legumes.	Small grain	Cotton	Corn or sorghum with summer legumes.
Do	Sweetclover	Sweetclover	Oats	Cotton.
Do	Oats	Sudan grass	Summer legumes	Corn.
Do	Oats; sweetclover	Sweetclover	Grain sorghum	Cotton.
Do	do	do	Wheat	Do.

[1] When vetch follows cotton it is planted in the cotton middles and plowed under the next spring. The vetch may be ollowed by a close-growing crop such as Sudan grass for hay or pasture.

Under Oklahoma conditions, a good cropping system is but a starting point n a soil-improvement program. Other measures and practices must be employed o arrest soil movement while the soil is being improved by the addition of rganic material and mineral elements. In project areas contour farming, strip ropping, and terracing are the measures used in conjunction with improved

IGURE 37.—*Growing soil-depleting crops continuously has caused crop yields to decline and has led to the abandonment of large acreages of land.*

crop rotations to hold soil in the field. All sloping land on farms under agreemen whether or not it is terraced, is farmed on the contour. The strip-croppin plans best adapted to this area are those shown in figures 14, 15, and 18. Th crop planted in the control strips may be a small grain, a winter legume, Suda grass, sweetclover, or other close-growing feed or forage crop.

There is little land in cultivation in southern Oklahoma that does not requi the protection of terraces. Some slopes of less than 2 percent are sufficientl uniform and, owing to soil type, are sufficiently resistant to erosion to requi only contour farming and strip-crop rotations as protective measures. In genera however, all slopes of from 2 to 8 percent that are to remain in cultivation a terraced. Owing to the erodible nature of most of the soils, slopes of mo than 8 percent can seldom be kept safely in cultivation. Such slopes are plante to permanent vegetation such as grass or trees in project areas.

Production of row crops is usually restricted to land sloping not more than percent. Terraced slopes of 6 to 8 percent that are to remain in cultivation a generally seeded to small grains and meadow crops which provide close-growin cover.

Water from terraces on farms under agreement is never turned into roadsi ditches unless such ditches are fully protected by vegetation or vegetation an structures. It is generally turned into pasture fields, woodlands, meadows, o in some instances, wide grassed ravines. When it is necessary to build outle channels to carry water to a natural drainageway, these are sodded. Bermud grass is used for this purpose in the cotton sections of Oklahoma; run-off fro 100 acres of terraced land has been handled satisfactorily by established Bermud grass channels. In instances where the soil type, slope, and quantity of wate to be discharged are unfavorable to the growth of vegetation, structures a placed across the channel at regular intervals to protect the terrace-water dispos system; and where overfalls occur in the drainageway, one or two structures a permanent type are used to drop the water to a stabilized grade and to protec the vegetated channel above. Such structures are made of loose rock, masonr brick, or concrete.

Cultivated fields that are to be converted into pastures and pastures tha are eroding are contour-ridged and sprig-sodded with Bermuda grass along th contours. To aid the spread of grass between ridges, several furrows are plowe each year toward the original ridge from each side. In 2 or 3 years under th treatment a pasture may become completely sodded if the ridges are not mor than 20 feet apart. Without such treatment the Bermuda grass will not sprea past the barrier of weeds and other vegetation which appear in the interval between ridges. Pastures which have a fair cover of sod, however, are contou furrowed and not contour-ridged.

A supplementary pasture program is devised for farms under agreement t provide relief for permanent pastures. Temporary pastures are provided fo the period when permanent pastures should be protected from grazing. Goo temporary pastures in the winter and spring permit a farmer to defer grazing of his permanent pastures until the grass has made good growth. Temporary summer pasture gives relief during drought periods and permits permanent pastures to reseed. The small grains, Italian ryegrass (fig. 38), and winter legumes are used to provide temporary pasture in the winter and spring; Sudan grass and, on soils well supplied with lime and phosphorus, sweetclover are used to provide temporary summer pastures.

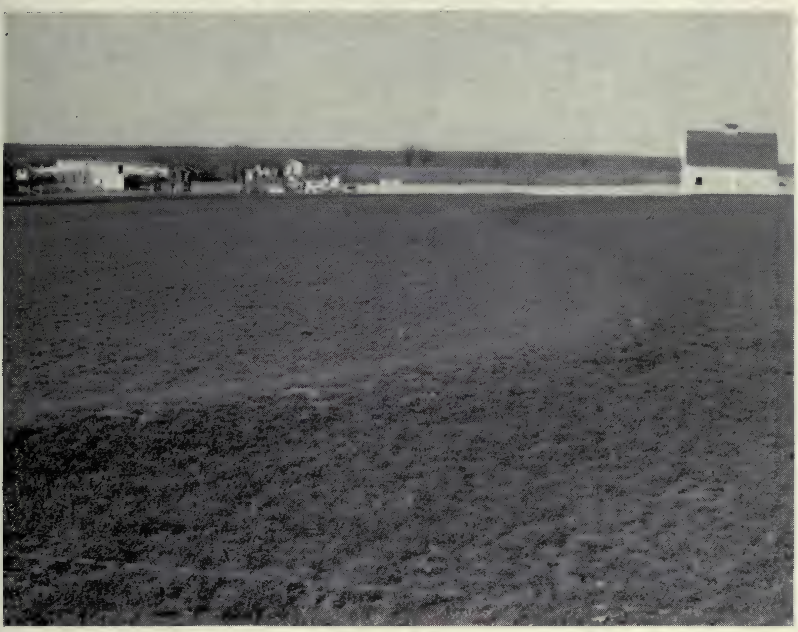


FIGURE 38.—*In southern Oklahoma, Italian ryegrass is used as a winter cover crop to protect the soil and provide winter pasturage.*

Burning weedy pastures, a general custom in southern Oklahoma, kills many desirable plants, destroys seeds of valuable species, and causes increased weed growth by eliminating competition from desirable plants. All of these effects of burning increase the erosion hazard. In project areas weeds are controlled by proper grazing methods and mowing, without the ill effects which follow burning (fig. 39). After weeds have become troublesome, mowing is perhaps the best method of destroying them. If the weeds are cut at the blooming stage, when the food reserves in the roots are lowest, one or two mowings a season are usually sufficient.

In project areas diversion ditches or terraces are constructed above gullied areas to carry water away from the heads of gullies that are cutting back into good land. Planting Bermuda grass and other vegetation in the gullies and placing inexpensive dams of rock and brush across their bottoms hasten stabilization. The larger gullies are fenced to keep out livestock.

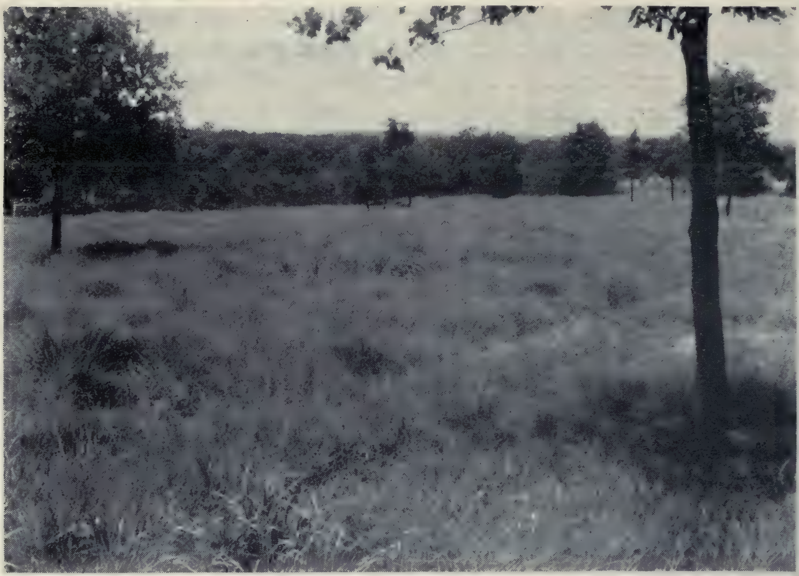


FIGURE 39.—*If a pasture field is protected from overgrazing and burning, native grasses will return, unless the field is too badly damaged by erosion. This Oklahoma pasture, once annually burned and overgrazed, is now properly managed. Native grasses, principally the little and big bluestems, now provide full soil protection.*

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SOIL DEFENSE
IN THE NORTHEAST

FARMERS' BULLETIN No. 1810

U.S. DEPARTMENT OF AGRICULTURE

FOREWORD

This bulletin treats of that part of the United States which is commonly referred to as the Northeast. The western boundary of the region here considered begins at the eastern edge of the Corn Belt in central Ohio. The Canadian line on the north, the Atlantic Ocean on the east, and the Virginia-North Carolina State line on the south complete the boundaries.

Evidences of soil losses are briefly touched upon, as are the factors contributing to these losses. The major part of the discussion deals with measures of defense that are now being employed on farms within project areas of the Soil Conservation Service and on farms in areas where members of C. C. C. camps have been assigned to erosion-control activities.

The many types of agriculture represented in the Northeast—general farming, dairying, orcharding, market gardening, and single cash crops such as potatoes—are more fully discussed in the last chapter, entitled "Outposts of Cooperative Defense," which describes six projects in typical farming areas.

Washington, D. C. Issued September 1938.

Soil Defense in the Northeast

By GLENN K. RULE

Soil Conservation Service, in Collaboration with
Subject-Matter Specialists

FARMERS' BULLETIN NO. 1810

UNITED STATES DEPARTMENT OF AGRICULTURE
1862 1889

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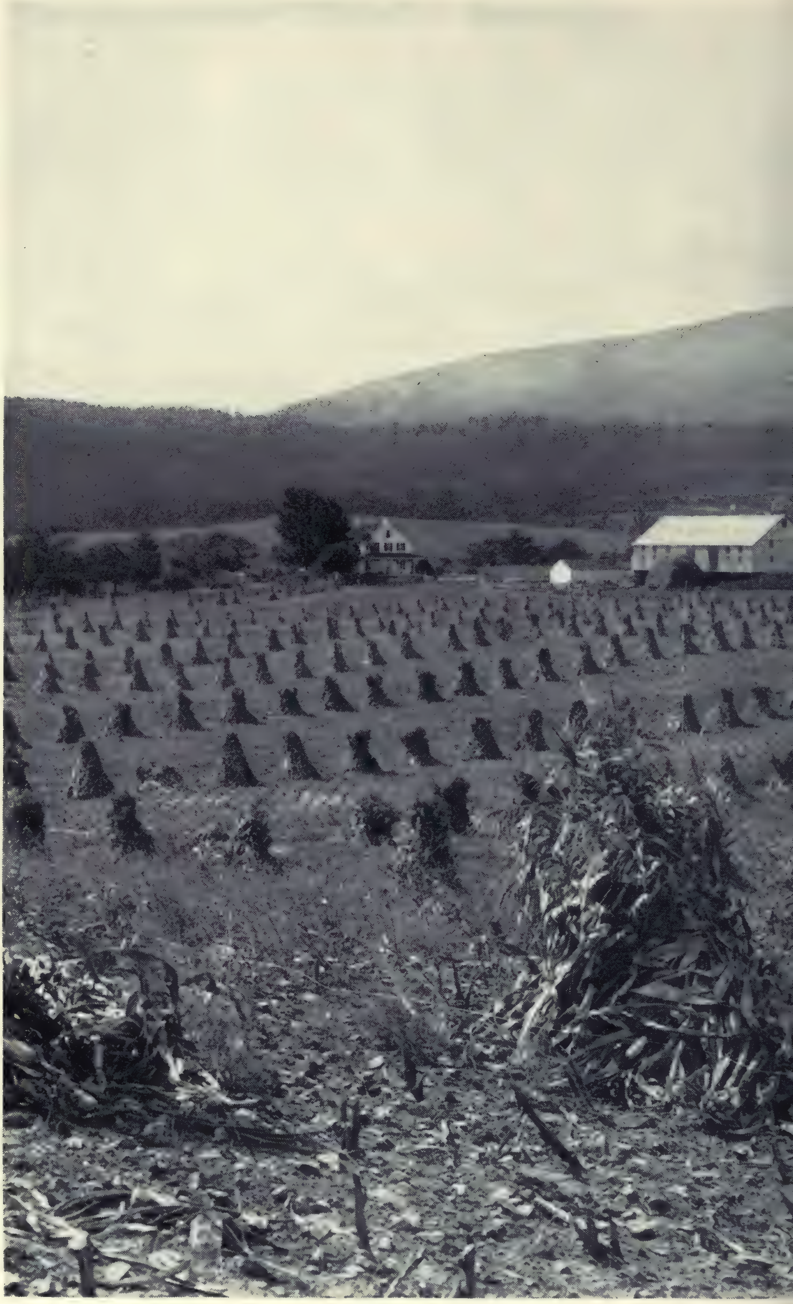


Figure 1.—Many pleasant valleys in the Northeast do not show severe soil losses from eros

A Soil Problem in Disguise

CLAD IN A MANTLE of vegetation—grass, shrubs, vines, and trees—the innumerable pleasant landscapes in America's Northeast seem to deny any present or past wastage of soil resources. From railroad windows passengers are heartened to gaze upon a countryside that seems to stay put. Vacationers and tourists see sparkling streams and lakes of clear water. And many farmers dwelling in peaceful valleys (fig. 1) are thankful that they not live where dust storms are common, or in one of many other regions here gullies are said to be making cancerous chasms in the earth and driving en from the land.

Casual reflection sustains this view. Ordinarily rainstorms are less violent an they are in the interior regions of the continent. And freezing weather d a normally heavy blanket of snow protect the land much longer during the ar than in regions farther south. The few gullies, in comparison with other eas, help to justify the complacent feeling of security in the stability of the land.

Damage by erosion, however, will be noticed by the observer if he looks at ecific areas in the Northeast. For example, some of these areas are: The bacco-growing section of Maryland; the trucking and fruit areas of New rsey; the tobacco-growing Connecticut Valley; the vineyards of New York; e area of Maine intensively growing potatoes; and the dairy section along the inooski River in northern Vermont. While soil losses in these localized gions are apparent, the greatest damage, in the Northeast as a whole, is caused the comparatively imperceptible effect of widespread sheet erosion.

Accelerated erosion, the man-made kind, started soon after our ancestors ttled along the Atlantic coast. For thousands of years, prior to their coming, ture labored slowly in building the soil. Meanwhile the country was in the stody of Indians, whose desires and activities were admirably suited to the eservation of natural resources. The Indian, it is true, taught the white man e use of agricultural practices which are now viewed as scientific marvels; yet e Indians cultivated only small patches of land near their villages, and these ere usually located on comparatively level tracts near tidewater, along a ream, or on the margin of a lake. Berries, fish, and wild game supplemented

the "three sisters" of their vegetable diet—Indian corn, beans, and squa
The Indian could thrive on this diet, but the white man found it difficult to
along without wheat.

Before our ancestors stood a vast forest that lifted in a billowy pattern to
highest summits of hills and mountains. This forest wall was a barrier agai
the food supply, and the necessity to subdue it is a compulsion understood
all men. In view of the dwindling food stocks and the uncertainty of replen
ments arriving by boat, it appeared imperative that the colonists clear the l
so that they might raise grain for bread. Some, it is true, notably the Fren
were trappers and traders; others—the Spanish particularly—were seeking g
but to all who sought a permanent abode the food supply was the vital probl

France, in claiming the vast interior region of the continent, temporarily hal
the westward surge of English colonists. Thus the clearing and cultivation of l
in the early days was confined to a narrow belt east of the Appalachian Mo
tains, extending from southern Maine to Georgia. Later, when French cla
were out of the way, the "floodgates" opened, and settlers poured through
Appalachian Mountain passes, laying the land bare by hacking, burning,
clearing as they went. "Fire, set loose," writes U. P. Hedrick in his History
New York Agriculture, "was the quickest and most efficient means of destroy
the forest growth." Frequently trees over a considerable area were gird
The resulting " 'deadenins,' when set fire," he adds, "made bits of fron
hells * * *."

Even in the early days a crude system of "resting" the land was adopted. It
described by an English traveler as the "infield and outfield" method. Abo
third of the settlers' holdings came under the plow at any one time. While
area was being exhausted and eventually given a "rest," another portion
cleared of trees and cropped. This process was repeated until the area
cleared had partially regained its productive powers, when it was again plow
This system, the English reporter revealed, was adopted not from a lack
knowledge, but from stress of circumstances.

Looking backward, one may understand to some extent the effects of the "ch
crop, and get-out" methods upon the soils of the agricultural lands from the
board westward through the forested area. The forest cover was removed f
the hilly and sloping lands making them vulnerable to erosion. Unquestiona
fire destroyed a considerable portion of the organic matter which had protec
the surface soil under forested conditions. It tended to bake the surface layer
soil and to change the open structure from a granular to a clodded condit
The lack of grass, noted and deplored by English travelers, prevented the us
a systematic crop rotation and the seeding of pastures. Cheap land enab
the pioneer to clear additional areas of his own holdings or to move to new a
when he became dissatisfied with his crop yields. In more northern portion
the region, climate favored the early invasion of bluegrass and wild white clo

Thus a volunteer pasture cover was given to many hills and slopes. Yet clover nd timothy as an artificial meadow-grass seeding seems not to have been used enerally until about 1835.

The trails of the principal single crops—wheat, corn, cotton, tobacco—had heir beginnings on the eastern seaboard. Wheat and corn marched inland over uch of the same area until corn found its permanent home in the Midwest. Wheat continued westward, spreading fanwise over most of the Great Plains. Cotton, with a quicker stride, swept south and west from the Carolinas and Georgia, leaving in its wake thousands of acres of racked soil which today is ittle more than an infertile waste.

Except in a few isolated instances, the Northeast did not lend itself easily to peculative, exploitative single crops which in the West and South were so nviting. Extravagant expectations were denied by the topography, soil, and limate. These natural conditions enforced thrift and a diversity of farming nterprises.

Farmers in the Northeast had their difficulties, however, when the expansive West opened and the ever-increasing volume of farm products came flooding astward. At about the time of the Revolution the Hudson River Valley was alled the "Bread Basket of the Nation." It competed for attention with the ich limestone section of Pennsylvania that had attained the title "Granary of he Nation." Later these titles shifted westward as canals and railroads opened resher and fresher lands farther and farther west.

Throughout the Northeast, in more recent years, land abandonment has been written indelibly in the agricultural record of practically every State. Just how uch of this abandonment has been caused by overcropping and competition rom the West or from other causes, nobody knows. It is clear now, however, fter a little more than two centuries of occupation, that erosion, and particu- rly sheet erosion, has been one of the major factors. Though a wounded soil—ter completely abandoned or devoted to pasture—may disguise itself with riars, sedges, devil's-paintbrush, and what not, giving the appearance of slow ecovery under a mantle of vegetation, it is probable that the soil is being washed ff the surface at a greater speed than it is being restored by natural processes. This inadequate cover of vegetation is incompatible with good soil husbandry nd good farming; nevertheless, it helps to create the illusion that the land is eing conserved—an illusion heightened by well-forested upper slopes.

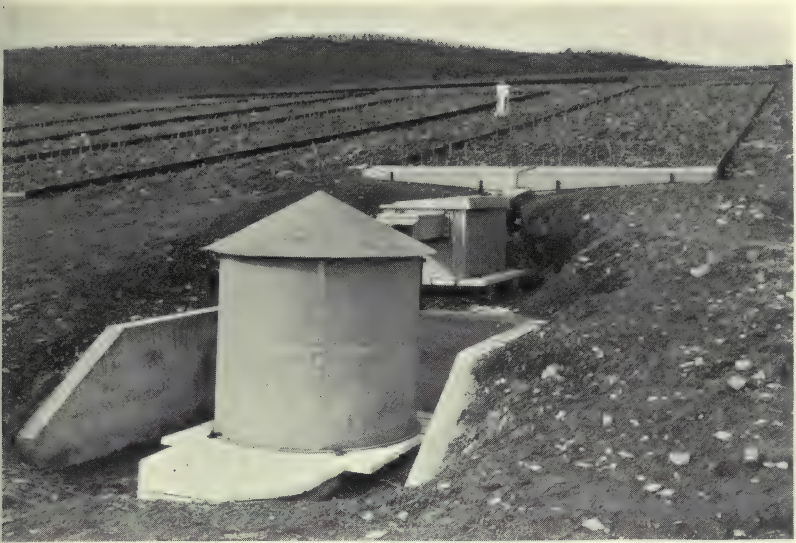
Under cultivation, for any considerable length of time, practically no soil in the Northeast grows profitable crops without the application of commercial fertiliz- rs. And, the trend has been toward heavier and heavier applications per acre. These increasingly heavier applications of commercial fertilizers, along with other mproved cultural and management practices, have tended to mask the ill effects aused by the loss of surface soil, and the removal of plant food through crops. Yields in many instances have been held even or perhaps increased, but the atural productive capacity of the soil has been impaired.

Lost Soil

ON THE ROLLING HILLS near Flushing, Long Island in 1903 J. A. Bonsteel was engaged in making a soil survey for the United States Department of Agriculture. Here the early Dutch settlers of Peter Stuyvesant's time had started their boweries or farms. Bonsteel saw two men near a stone fence loading soil into a two-wheeled, one horse dumpcart. When filled, the cart was drawn up the hill, and the soil was spread upon an almost barren knob

With a soil auger at hand, Bonsteel bored into the earth on the uphill side of the fence near the spot where the men were digging. His auger went down and down almost 2 feet before going beyond the rich accumulation of topsoil that had been washed there from the hill. Pressed for an explanation, the men said they had a little spare time and that they believed it was cheaper to haul the dirt back than to buy stable manure. Under the prevailing economy of the time, Bonsteel estimated that it would cost $500 an acre to lug even a 6-inch covering of that soil back to the place from which it came.

Bonsteel was one of the soil scientists who was early impressed with the seriousness of soil losses by erosion. Yet only recently has erosion emerged from the realm of discussion to the realm of measurement. In 1917 M. F Miller and F. L. Duley, of the Missouri Agricultural Experiment Station installed the first measuring device to record soil and water losses under various crops and conditions. Their method, though now somewhat refined and improved upon, is still standard. Strips of soil, of the same slope, lying side by side up and down the hill, are surrounded with treated wood or metal to prevent the entrance of run-off water or soil from the outside (fig. 2). At the foot of each strip devices are provided to measure the soil and water loss. These strips are planted to crops and rotations of crops that prevail in the region Experiments such as these are now being carried forward and extended by 15 soil conservation experiment stations, three of which are in the Northeast (see back cover page), and by many State colleges and experiment stations Findings at these stations provide the basis for our recent and more exact knowledge of soil removal.



IGURE 2.—Equipment such as this provides measurements to determine the extent of soil and water losses.

By and large, under natural conditions topsoil is removed no faster than it is eplaced in the slow building processes from beneath. Under these natural onditions there is some erosion, but this is not serious.

But if you remove nature's cover of thick grass, trees, vines, and shrubs, and f you pulverize the soil year after year as in continuous row-crop farming, you erange the natural balance of soil formation. Soil is then taken from the top uch faster than it is being rebuilt below. Present-day high-powered machin- ry, though it may help temporarily to unlock plant nutrients, hastens the rocess with an acceleration that is thoroughly modern.

Sheet erosion, the most imperceptible type, yet by far the most damaging, emoves thin films of soil, layer by layer, from unprotected land. The surface, nder sheet erosion, is usually smooth looking, and the lost soil well-masked. urthermore, sheet erosion is a selective process; it takes the most productive art of the surface soil first, leaving the less productive on the field.

Gully erosion may have its inception at any time, but it usually follows after bout one-half to two-thirds of the topsoil has been lost through sheet erosion. oving down unprotected slopes, silt-laden water, accumulating from con- erging smaller slopes, forms slashing streams that etch out gullies (fig. 3). hese gullies may in time eat into the earth until they strike bedrock. And hey may march up the slope to the crest of the hill, making it impossible to ultivate the field. Yet in the impoverishment of most fields, gullies play a mall and incidental part. They are the belated evidence of an advanced stage f sheet erosion.

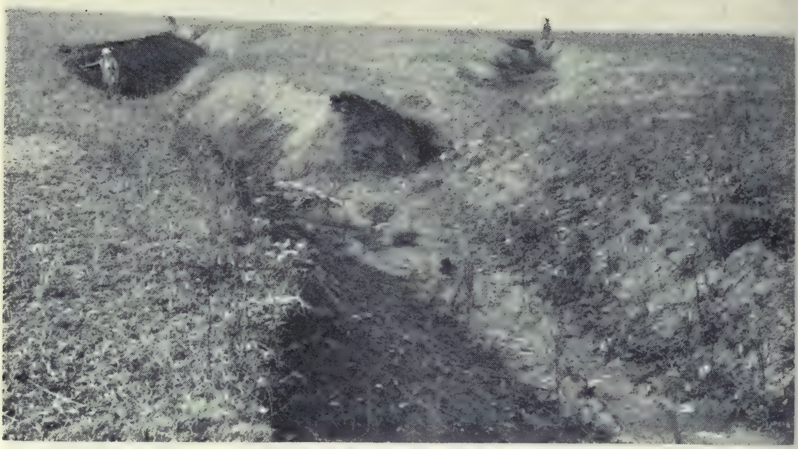


FIGURE 3.—Gully erosion usually follows after about one-half to two-thirds of the topsoil has bee lost through sheet erosion.

Soil scientists in 1934 examined the surface soil in a general survey of innumerable areas throughout the country to determine the extent of erosional damage The results of this survey, in the main, have focused the attention of the Natio upon the amount of topsoil lost by erosion. Here in the Northeast, when a figures were assembled and analyzed, the loss of surface soil ran beyond a expectations; yet the loss in tons in no way compares with the more intensivel cultivated regions of the Middle West and South. Briefly, the results in th Northeast show that more than one-third of the region has been damaged b sheet erosion—the damage varying from slight topsoil losses in some places t the loss of all the topsoil and considerable subsoil in other sections. Gull erosion, varying all the way from slight to very severe, has affected probabl 20 percent of the region.

While the loss of surface soil, as expressed in inches or tons, may be small i comparison with other areas, yet the actual damage may be more severe. Th original surface soil over most of the area probably had much less depth than tha of the Middle West. In vast areas of the Middle West the original surface soil or topsoil, measured from 16 to 20 inches or more in depth. Thus a 4-inch los of surface soil in the Northeast probably causes more land impoverishment o abandonment than would an 8-inch loss in the richer soils of the Middle West

To many farmers erosion is not a problem until gullies have made it impossibl to cultivate fields in a normal way. So long as miniature gullies can be crosse with farm tools and thus become obliterated, the soil loss is frequently no appreciated. Though gullies have been rubbed out, washing will continue, an if rains are severe more gullies will form. The gullies are bothersome and make farming operations more difficult, but they signify a condition that is far worse than the inconvenience they cause.

Soil material carried to the ocean consists of colloidal matter, clay, silt, nd the finest grades of sand. From this material crops can extract plant utrients more easily than from the coarser soil particles.

Not all of the washed soil ma- erial goes as far as the ocean. Much of it is deposited in reser- oirs, lakes, swamps, flood plains f streams, and the base or flatter arts of slopes. This loss of soil, cientists now believe, is many imes greater than the total lost n the sea.

Run-off water carries soil par- icles which embody plant nutri- nts. In addition this run-off vater carries immense quantities f fertility elements that are in olution. These dissolved nutri- nts may have been purchased in relatively expensive form as ommercial fertilizers. They may e replaced at a considerable xpense, but this loss in no way ompares with the loss of the ody of the soil itself. Further- ore, this soil can never be re- urned to the fields whence it ame at an expense that can be stified. It is gone.

Existing water-power plants, ither those in use or those bandoned, indicate much that as happened on the watershed hich feeds them. In such a ell-forested region as the Adi- ondack Mountains many of these ld water-power plants continue o operate (fig. 4). The stream ow is clear and fairly uniform ue to the forest cover.

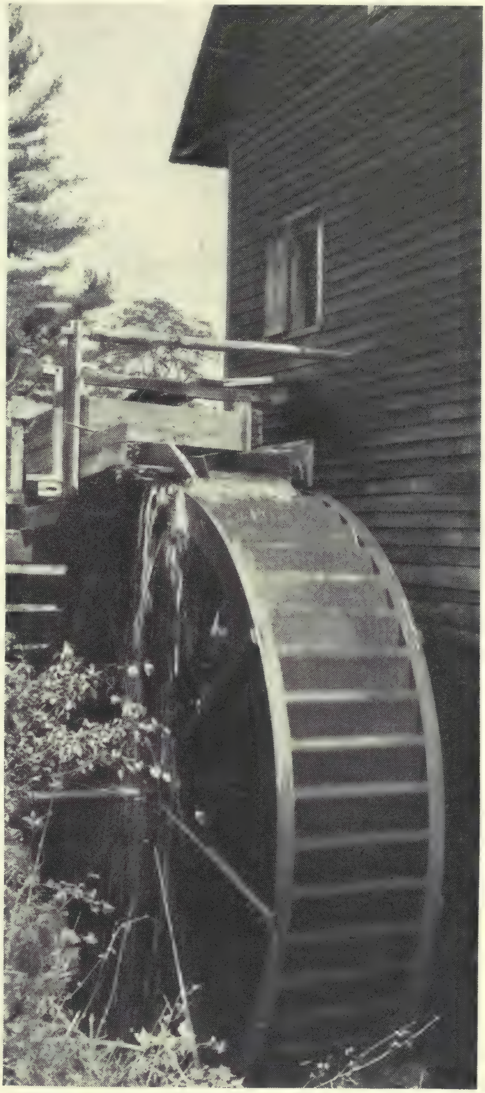


FIGURE 4.—Many water-power plants continue to operate in the Adirondacks. The stream flow is usually clear and fairly uniform due to the forest cover.

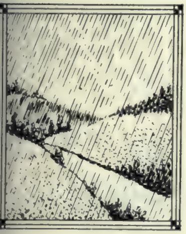
As a contrast, consider the farming community adjacent to Ithaca, N. Y., a the foot of Cayuga Lake. Eleven dams have been built on various streams i the past. Seven of the eleven ponds are now completely filled with silt. Thre of the remaining four are located on one creek and are only partially functioning The fourth, still in service, is the Ithaca city water reservoir. Built in 1910 this dam had an original capacity of 357 million gallons of water. Twenty-fiv years later (1935) engineers figured that the capacity had been reduced to 27 million gallons, a decrease of about 23 percent. Rough, but conservative, calculations indicate that during the 25 years the reservoir received an average o 83 tons of soil from each cleared acre of land in the drainage area.

Farther south (in northern Maryland) many formerly thriving river ports ar closed to all but the smallest of crafts. Joppa, on the Bush, was once the tobacc metropolis of Harford County when tobacco was the prevailing crop. Toda silt prevents boats of cargo size from docking at the port. As late as 10 year ago fair-sized steamers made frequent trips up the Susquehanna, docking a Port Deposit. Though some skippers will occasionally make the trip now, th shifting shoals of silt discourage most of them.

Among their endeavors to gain unrestricted control of the Chesapeake (Wa of 1812) British seamen pursued an American gunboat flotilla up the Patuxen River in August 1814. This river roughly parallels the Potomac and is abou 18 miles east of Washington in its more northern extremity. Rather than submit to capture, the Americans sank their boats in the river near Nottingham Folks now living tell about the souvenirs which plucky divers later recovere from these shallowy submerged crafts. But today, silt prevents all but th smallest boats from entering these waters. Up the river, at Upper Marlboro tobacco scows once docked immediately back of the Episcopal Church. Th church still stands, but silt from the countryside has filled the harbor. It is swamp today.

The purpose of this bulletin is not to dwell at length on the loss of soil through erosion. Rather an attempt is made to outline the best known procedures fo stopping the loss of the remaining topsoil and to explain the measures that ar now being taken by the Soil Conservation Service in cooperation with the ma on the land. Topsoil could be preserved in the Northeast, as elsewhere, if al of the land susceptible to erosion were restored to nature's protective mantle o vegetation. Yet men must get their food from the land, and the obvious and sensible policy is to safeguard all areas with the best known and most appropriate devices to hold soil while deriving a living from it.

Climate, Slopes, Soil, and Crops



THE PRINCIPAL FACTORS affecting soil erosion are: (1) Distribution and intensity of rainfall; (2) the topography of the land, which includes the degree of slope, and the total slope area drained by the individual drainageways; (3) the erodibility of the particular soil type; and (4) the type of soil management practiced, with special reference to the vegetative cover.

Climate

At Culebra, Isthmus of Panama, our Government found that vegetables could not be raised successfully without irrigation despite an annual rainfall that averages 86.64 inches. The profuse rains (more than twice as much as received by farmers in the Northeast) come at the wrong time of year for the benefit of plants.

Soil erosion, as well as crop production, is closely linked with rainfall; however, it is the distribution throughout the year and the intensity of individual rains rather than the total amount that must be reckoned with. We Americans est about the English who are said to go through life with an umbrella or raincoat at hand. Yet for the last 35 years the rainfall at Camden Square, London, has averaged but 24.47 inches, as compared with the 30 to 50 inches in our Northeastern States. Frequent gentle showers rather than infrequent pelting rains characterize the weather in the British Isles.

During several months of the year the northern areas of the region are usually well protected by a blanket of snow. Snow protects the vegetative cover of grasses, legumes, and winter grains by preventing frequent freezing and thawing of surface soil. This cover makes it less susceptible to wash from late winter rains. However, later, when spring rains and higher temperatures come, usually in March and April, the snow melts, and it is during this period, when water from melting snow is added to the normal monthly rains, that the most startling losses of soil occur. Snow and rain during March, April, and May make up 20 percent of the total annual precipitation for the region at all of the ower altitudes and increase to 25 percent or more at all of the higher elevations.

This is the period when destructive floods usually visit the estuaries above tidewater and deposit rock, sand, and silt from eroded fields and stream banks. It is in this period, likewise, that startling damage is visited upon villages and cities adjacent to streams and rivers.

June and July is another period when land suffers from heavy rains. During these months spring- or fall-sown grain and intertilled crops are inadequate to hold the soil. Either the surface of the ground is bare because of preparation for tilled crops like corn, potatoes, or tobacco, or it is inadequately protected by the rough growth of winter wheat, spring wheat, oats, and barley.

On June 19, 1936, rain gages at the Soil Conservation Experiment Station, Arnot, N. Y., recorded 1.46 inches of rain, 1 inch of which fell in 10 minutes. On a plot of cornland (72 feet long and on a 20-percent slope) 7,586 pounds of soil were lost, along with 45 percent of the water, in this brief period. During the next 6 weeks only 1.7 inches of rain fell and crops suffered. A single rain is frequently responsible for a large percentage of the soil and water losses of the season.

Slopes

A boy on his sled knows that he can travel faster down a steep slope than on one that is less steep. He also knows that he may start slowly but will pick up speed down a long gentle slope.

Water, likewise, runs faster down a steep slope than it does on one less steep, other factors being equal, and fast-moving water is very erosive. Long slopes, even if gentle, permit water to gain speed, and this increased speed, along with the increased volume, accelerates the eroding power (fig. 5).

To conduct water safely down a long, steep slope over a drop of several hundred feet in elevation is always a difficult job. Stabilized outlets may be difficult to find. Moreover an outlet that is stable for a normal quantity of water may become unstable if an increased concentration of water is thrown into it. New gullies may appear, creating a more difficult problem than the original.

Soil

When we think of soil as related to erosion, at least two soil properties must be kept in mind. One is the rate of absorption, and the other is the water-holding capacity.

Coarse-textured soils, such as sand and sandy loams, resist erosion because they permit rain water to enter more readily and thus reduce or eliminate run-off from normal rainfall. These coarse-textured soils, however, frequently contain insufficient fine material to bind particles together and so permit erosion. Again, coarse soils may hold such small amounts of water during a drought that plants suffer and the vegetative cover is impaired.

Fine-textured soils, at the other extreme, clays and clay loams for example, permit rain water to penetrate more slowly. A greater percentage of water falling on these soils may be lost even on a moderate slope. If water is once taken up by these soils, however, it is held available for growing plants, and droughty periods will have less effect than on the coarse-textured soils.

Pattering raindrops on many fine-textured soils developed from lake-laid deposits dislodge particles with ease. Once in suspension, these small particles may be carried by even slowly moving water. For example, the Dunkirk soil, found along the comparatively level Ontario Lake plain, has been observed to erode on land sloping less than 3 feet for each 100. Under cultivation this soil requires astute management to prevent severe soil losses.

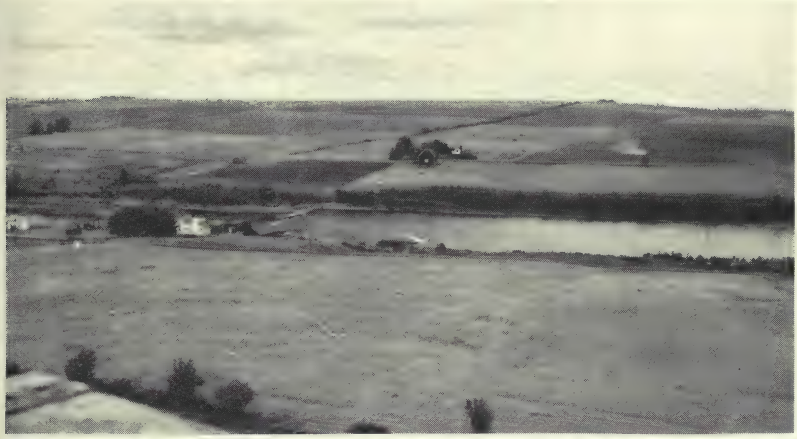


FIGURE 5.—Long slopes, even if gentle, permit water to gain speed and volume thus accelerating the eroding power.

Organic matter is destroyed or depleted when intertilled crops, such as potatoes, corn, and various truck crops are grown on the same land year after year. By increasing the organic matter in these soils the tilth and physical condition are improved. The organic matter serves as a sponge to absorb water, and it tends to give soils the desirable granular condition. In a well-granulated soil the particles cling together and act as a unit physically. This improved physical condition permits water to enter these soils more readily and to be held available for plants. Consequently water that is absorbed and held by the soil cannot be lost by percolation or by run-off.

The absorptive capacity of a soil is not entirely determined by the topsoil. A loose, porous, and deep surface soil is highly desirable, but a man who owns a farm on which the subsoil is open and permeable usually has a decided advantage over the man on whose farm the subsoils are tight and impervious. When the latter type of soil has absorbed all of the water which it will take, and this is limited, any additional water must run off the surface. Occasionally, however, one may find a surface soil that leaches so readily that an impervious subsoil ma check the downward passage of plant nutrients and thus prove beneficial.

Crops

If we place the names of all crops in a list and arrange them by groups in orde of their ability to protect soil we shall find a wide difference. Grass, shrub trees, and permanent hay including alfalfa and clover, will top the list. At th bottom we find the worst offenders, the row crops such as potatoes, corn, tc bacco, and truck crops. Between these extremes we find an intermediate grou the small grains such as oats, wheat, rye, barley, and the various annual legume

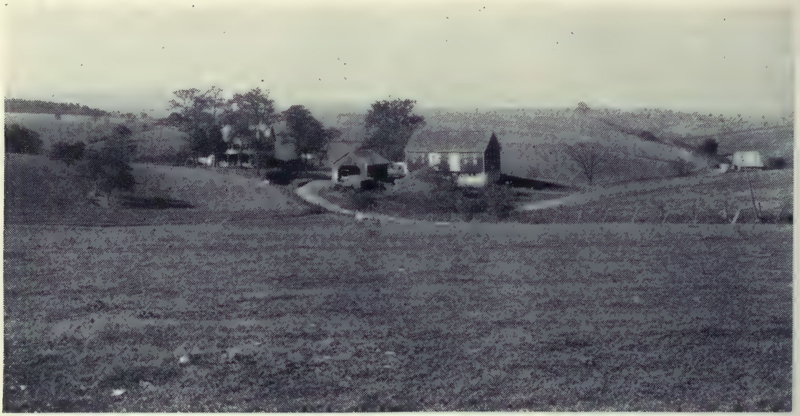


FIGURE 6.—Thick grass protects the soil against the lash of rain and the rush of water.

It is obvious upon examination why certain crops vary in their ability to pr tect soil. Grass, with its innumerable blades above ground, prevents rain fro striking the soil (fig. 6). Underground the maze of entangling roots holds th plant and soil in place. These decaying roots leave passages for air and wate and the increased supply of organic matter increases the absorptive capacity c the soil. Trees, with their overhead canopy of leaves and branches, check th pelting force of raindrops (fig. 7). The thick mulch of decomposing leaves an twigs on the surface soil and decaying roots below, permits water to ent readily, thus reducing the run-off. Corn, potatoes, tobacco, and truck crops a usually planted in rows widely spaced. The intervening soil is stirred an pulverized to kill weeds. This produces a finely pulverized soil, often a du mulch, which is easily whisked away by rushing water. The so-called clos growing crops such as wheat, oats, rye, barley, and the various legumes are neve intercultivated; but caution must be exercised even with these if the land is stee or if it does not absorb water readily. Under these conditions the drill row should run on the contour, and the long slopes should be broken with stri crops, diversion terraces, or terraces.

On the low rolling foothills of the unglaciated Appalachian region near Zanesville, Ohio, tests have been made comparing the erosion-resisting qualities of crops on the Muskingum silt loam. On this land, sloping 12 percent, plots were laid off to compare the water and soil loss when corn is grown continuously; corn, wheat, and grass in rotation; and grass alone. Over a 2-year period (1934–35), and under a rainfall averaging 34.5 inches annually, 35.2 percent of the precipitation was lost when the land was planted continuously to corn. Nearby, on plots handled under a rotation of corn, wheat, and grass, the water loss amounted to only 18.4 percent of the total rainfall and snowfall. The bluegrass plot, also nearby, lost only 4.5 percent of the precipitation.

The corresponding annual soil losses were: From land devoted continuously to corn, 59.6 tons per acre; from land in rotation, 8 tons per acre; and from land covered with bluegrass, a mere 100 pounds per acre.

At these rates, it would require only 19 years to remove 7 inches of topsoil from land planted continuously to corn, 145 years to wash off an equal depth of soil under the crop rotation, and 23,200 years to carry away as much topsoil from the field in bluegrass.

FIGURE 7.—Trees provide excellent protection against erosion.

Defense Measures

FARMERS CAN DO NOTHING TO CONTROL
alter the climate, nothing to change the natural topograph
of their land, nothing to change the basic materials fro
which their soil was derived. Most farmers can, howeve
crop their land more skillfully, do something to make the
soils more permeable to rainfall, and thus reduce the amou
of water which now journeys to the rivers and the ocea
carrying away soil. Improving the porosity of the soil a
so trapping more moisture, may have as its immediate goal a greater financi
return from an increased crop. The motive matters not so far as erosion is co
cerned, because soil is saved whenever less water is permitted to flow over t
surface.

In humid regions like the Northeast it is impossible, at all times, for the soil
absorb all of the water that falls on the land. Water that is not absorbed by t
soil must be disposed of, and the degree in which it is marshaled safely off t
land largely determines the extent of erosion control. All methods of conducti
this surplus water safely off the land are based upon the simple principle of chec
ing the rate of flow. Slowly moving water drops its load of silt, and the cutti
power is reduced. These principles are involved in all control measures, bot
new and old.

Farm Management

Most farmers can look over their land and recall past mistakes of their own
of previous owners. Here is a field, for example, that should have been left
timber; there is a slope that should have been left in pasture or meadow; ro
crops did well on still another field until the organic matter and fertility we
depleted.

To a degree, influences outside or off the farm such as transportation facilitie
distance to market, real estate values, consumer whims and desires, to name
few, may govern the particular crops grown on the farm. The desire to suppl
products for a temporarily favorable market may push the plow onto grass
slopes that should never have been opened to the wash of rains. Or the necessit
for meeting current financial obligations may make it seem necessary for t

wner to follow a punishing type of soil husbandry against his own best judgment. These problems are not easily solved, and it takes a high type of farm nanagement to preserve soil resources and at the same time resist the urge for reater immediate gain rather than the benefit of more modest returns over a eriod of years. It is a choice of making changes deliberately to preserve soil esources or having more unwelcome changes thrust upon one after the soil s gone.

The most important initial step in the control of erosion is placing each parcel f land in the crop or rotation of crops to which it is best adapted. If the steeper lopes cannot be kept in a productive pasture through improvement practices, hey should be planted to trees. If land now under cultivation and given the dvantage of soil conservation practices cannot be farmed on a sustaining basis t should be converted to pasture or meadowland.

The erosion-control practices discussed in the following pages are not offered s one-two-three measures for farmers to apply. Rather each of the present nown methods is briefly discussed so that farmers may select intelligently the ombination of practices best adapted to their own requirements.

Contour Farming

Our inherited rectangular system of farm lay-out of land has enforced field rrangements that are inappropriate for a rolling countryside. It has been said hat this system "tried to fit square farming to a round country." As a conseuence many farms lie in a long narrow strip leading from a valley up the grade o a plateau at the crest of the hill. To aggravate this situation these farms have requently been subdivided lengthwise into several fields. Farming these long ields up and down the slope has been a direct cause of severe soil loss.

There are a number of obvious reasons why fields should have been laid out n the contour or across the slope. Plow furrows around the slope make a eries of soil dams that hold water on the field, giving it more time to soak in ather than run off; harrow teeth leave smaller but more of these obstructions, nd cultivator teeth leave similar grooves on the soil devoted to row crops durng the growing season. Since grass seedings or mixtures of grass seedings are sually made as the grain is being drilled, or soon after, much of this seed falls nto or is washed into the drill furrows. Consequently, both the plants of the urse crop and the grass plants emerge in contour lines. The resulting rows of rass on the contour more effectively check the flow of water than they would if hey ran up and down the slope.

Farmers who have tried contour farming report that field work is much easier n man and team because all machinery is drawn on the level (fig. 8). Present vidence indicates that much less power is required to farm on the contour than oing up and down the slope.

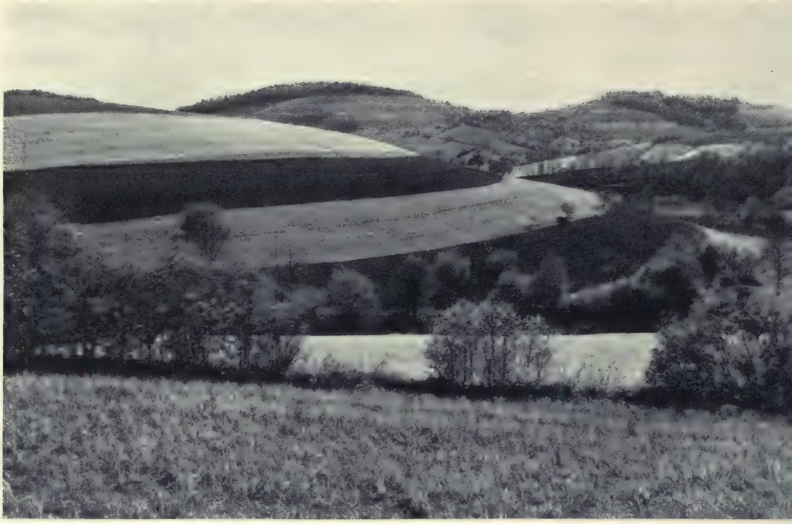


FIGURE 8.—This Pennsylvania field is being farmed on the contour or around the slope on the le
Farming around the slope, instead of up and down, makes easier work for man and team

Strip Cropping

Strip cropping is a proven device for holding soil. Though it has be employed by farmers in a few scattered communities in the Northeast for ma years, the recent widespread interest in this practice came as a result of numerous cooperative field demonstrations conducted by farmers with Soil Conservation Service. A few farmers in northwestern West Virgin southwestern Pennsylvania, and southeastern Ohio have strip-cropped th fields for over 25 years. An Ohio farmer who has strip-cropped his farm since 19 says: "We would not think of going back to the old way of plowing a whole fiel

To strip-crop a field, one plants the crops in long and relatively narrow ba of approximately equal width across the slope on the contour. Clean-til crops such as corn, potatoes, and tobacco (all erosion-permitting) are alterna with grass, small grains, and legumes (all erosion-resisting) (fig. 9). Unl exceptional conditions are encountered, there should be little deviation fr the true contour. Safe deviations from the true contour are based upon particular type of soil; these conditions should be known before any attempt made toward laying out a farm for strip cropping.

Soil-laden water flowing down from the clean-tilled strips encounters the ba of thick vegetation in the next strip below. Since the rate of flow is checked the stems of plants, soil is deposited. And, since the water has been ma almost clear by this filterlike action, it enters the soil more readily because th are fewer soil particles to seal the downward passages. If row-crop strips given this protection from the wash above, and if there is another strip below eady to catch soil and water, little damage need be expected from any except he heaviest of rains.

Whether strip widths should be narrow or broad will depend on the degree nd length of slope, absorptive and water-holding capacity of the soil, rainfall, nd other factors. On the Soil Conservation Service project areas and in areas vhere members of C. C. C. camps have been assigned to aid in erosion control, trip widths are being studied under a wide range of conditions, and also at rosion experiment stations. In general, present information indicates that trip widths may vary from 50 to 125 feet. Some soils on steep slopes may wash ven if the cultivated strips are less than 50 feet, while other soils may not erode everely if the cultivated strips are 125 feet in width. Strip cropping is a flexble practice; hence, if the original strips are found to be too narrow or too wide hey may be corrected easily.

In practice it is desirable, where possible, to make the cultivated strips of uniform width to eliminate point rows. It is also desirable for a farmer to consider vidth of strips in relation to his implements. If a farmer grows potatoes on a ommercial scale he should lay out the strips of such a width that he will make he most economical use of the various tools used throughout the season. He will vish to figure closely how many round trips would be necessary with his sprayer r duster. He would not want the strips of such width that it would be necessary to dust or spray one row. If he has a two-row digger he would not want an neven number of rows in the strip.

In areas where corn is regularly grown in the rotation many farmers prefer aving the width of cultivated strips determined by the number of shock rows of corn. For example if the slope is steep the strip may be just one shock row vide. When strips are but one shock row in width most farmers prefer to shock heir corn on the edge of the adjacent meadow strip (fig. 10). This practice per-

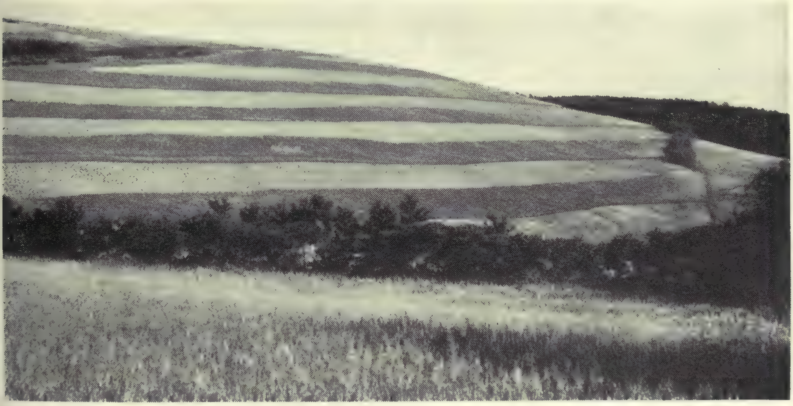


FIGURE 9.—Strip crops as applied to a New York field.

mits the solid drilling of wheat on the strip from which the corn was removed, and husking is a more pleasant task later in the fall. This practice may be used if there are two shock rows of corn in the strip, but of course it means that half of the corn stover must be carried a greater distance to the edge of the meadow strip. If a portion of the corn crop is to be made into silage, it is possible to harvest this corn from the middle of the corn strips and thus reduce the distance that the remainder of the corn need be carried. This, however, necessitates cutting one row of corn by hand, through the middle, to permit the use of machinery.

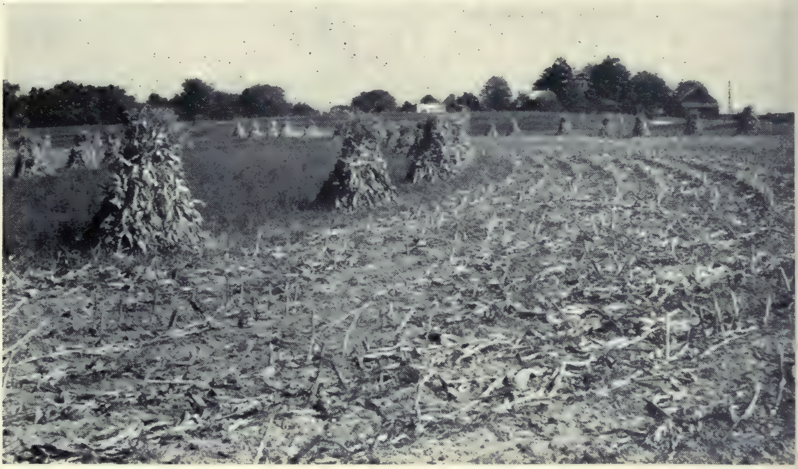


FIGURE 10.—Corn shocks have been placed on the adjacent meadow strip. In this way wheat may be seeded in the entire strip from which corn was removed

Let us assume that a farmer has a sloping field and that he wishes to strip-crop this field, using a rotation of corn, small grain, and hay. Figure 11 shows how this may be accomplished and any serious derangement of the cropping sequence avoided. If a rotation of potatoes, wheat, and hay is preferred, the adaptation can be just as easily made. Likewise the longer rotations, which include a greater variety of crops, may be used. The important point to remember is that strips in row crops should be protected from above by strips of thick-growing crops.

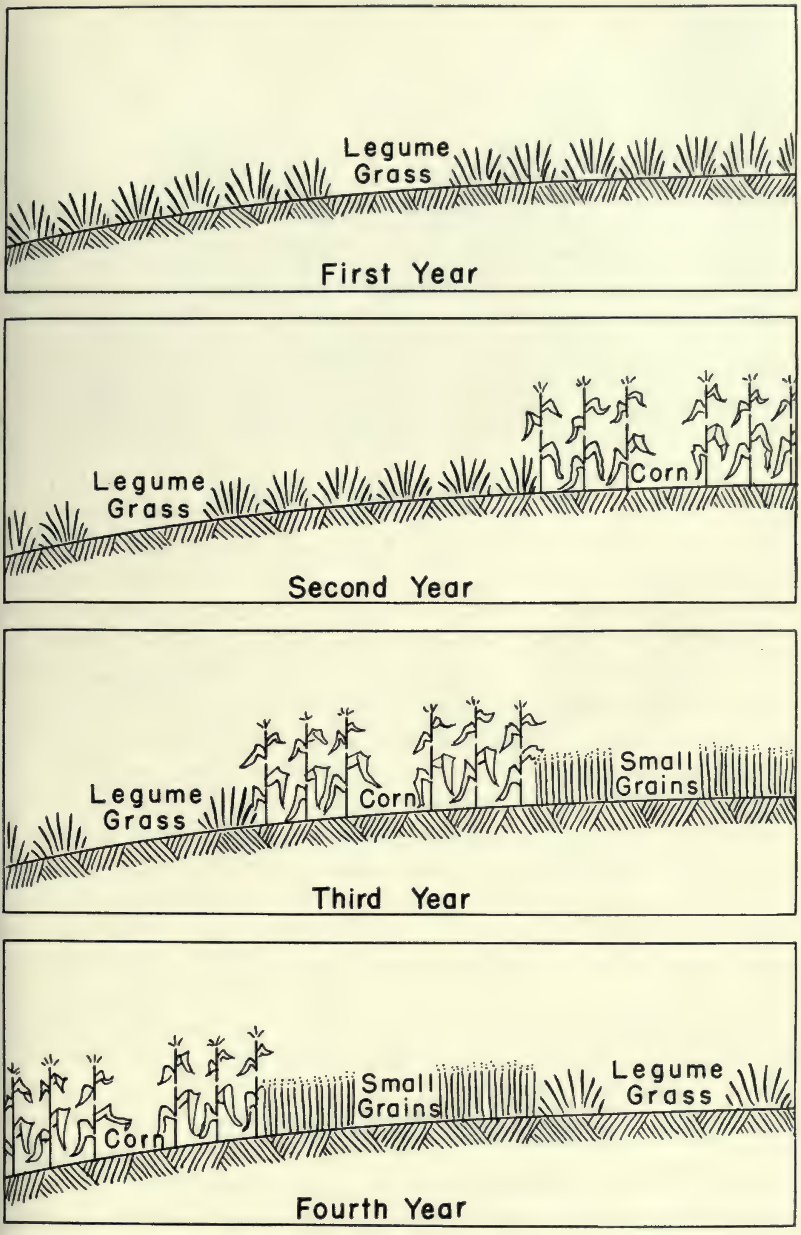

Legume
Grass
First Year
Legume
Grass
Corn
Second Year
Legume
Grass
Corn
Small
Grains
Third Year
Corn
Small
Grains
Legume
Grass
Fourth Year

FIGURE 11.—Showing how strip cropping may be started in a field.

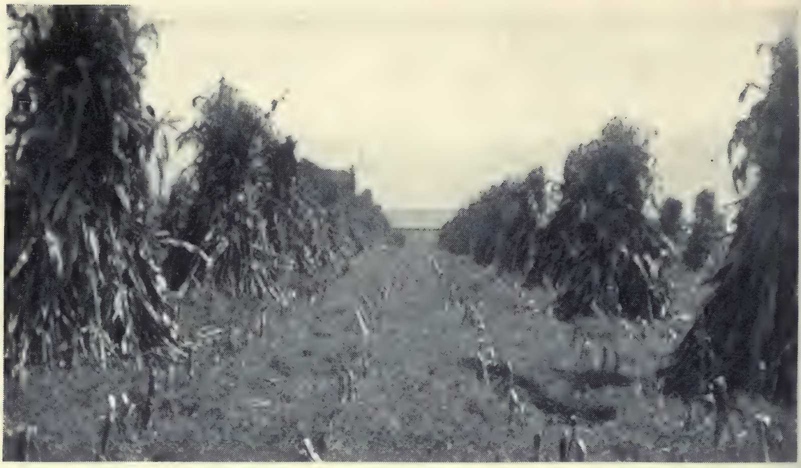


FIGURE 12.—Sweetclover was seeded in this Lancaster County, Pa., field during the last cultivation of corn. A good winter cover is assured.

Cover Crops

Winter cover crops can serve a twofold purpose in the control of erosion. (1) They protect the soil against dashing rains during the fall, winter, and spring, when no regular crop occupies the land. (2) When plowed under, if they have attained sufficient growth, they increase the organic-matter content of the soil, thus making it more absorptive of water. Rye, wheat, and several of the legumes may be seeded for a cover crop following the last cultivation of corn (fig. 12). If seeding is delayed until after the corn is harvested, in the northern area, the cover crop attains insufficient growth to give adequate protection.

In the more northern areas it is likewise a difficult problem to find a satisfactory cover crop for land on which potatoes are grown. The potatoes are usually harvested so late that the cover crop has insufficient time to establish itself adequately to constitute a protection against erosion.

In the southern areas winter grains are common crops in the rotation, and they normally attain sufficient fall growth to give some protection to land during the winter and spring months, making the use of cover crops, as such, unnecessary.

Grassed Waterways

Most cultivated fields in the Northeast have depressions or draws which serve as paths for surplus water. If these paths are kept permanently in grass they provide an excellent means of conducting water safely off the field. Everywhere one may find a few farmers who have a commendable and instinctive reluctance to plowing through these paths. Far more frequently one finds farmers who

ill not take the time to lift plows or cultivators, or straighten disks when
ossing these watercourses. A terrace system, if properly built, always
ovides facilities in the form of terrace outlets for the safe disposal of surplus
ater after it has left the terrace channels. It is fully as important to provide
ıd protect similar facilities on fields that are being strip-cropped or contour-
rmed. Grassed waterways in strip-cropped fields serve the same purpose as
rrace outlets on terraced fields.

There are two types of grassed waterways. One type, used in connection with
rip cropping or contour farming, is comparatively broad, and the area included
the waterway is kept permanently in meadow. The other type is more often
sed in connection with diversion ditches or terraces particularly where natural
epressions do not occur. It is comparatively narrow, and the waterway is given
thick, low-growing, turf-forming type of vegetation that will fold down
ıder the pressure of water, like shingles on a roof.

The grassed waterway used in connection with strip cropping or contour
rming is seeded with the same grasses or mixtures of grasses that are seeded
ı the meadow strips (fig. 13). Hay is harvested from the waterway and the
rips at the same time. The seedings include the grasses and legumes that
e adapted to the region. Bromegrass and orchard grass are among the newer
ecies now under trial in many of the project areas.

A common mistake in laying out waterways in a strip-cropped field is to
ake the area too narrow. An adequate width for erosion control will depend
on the size of the drainage area, the tilt of the land, the width of the strips,
e type of soil, and the rotation followed. All of these factors must be con-
dered; yet many farmers are finding that it is easier to maintain the grass areas
they are much wider than is absolutely necessary for erosion control. And fur-
ermore they are finding that these areas may frequently produce the highest
ıy yields on the farm or good pasture if they can be made accessible to stock.

The grassed waterway used in connection with terrace outlets or diversion
rrace outlets is seeded with various combinations of grasses and legumes.
hese combinations usually include bluegrass, bentgrass, Ladino, white clover,
ıd in southern areas, lespedeza. A mixture of grasses usually gives the best
sults. If seasonal conditions are unfavorable for one species another may
ake sufficient growth to give some protection. These low-growing grasses
ıd legumes should not be cut for hay although they may be pastured by tether-
g animals upon them. Care must be exercised, however, to see that the turf
not damaged by trampling.

To establish a dense cover it is frequently necessary to increase the organic
atter and fertility of the soil by an application of manure and phosphate.
Iulch is frequently used at the rate of 1 or 2 tons per acre. The mulch is held
place with chicken wire until the new seeding becomes established; after
ıat the wire is removed and may be used in another location.

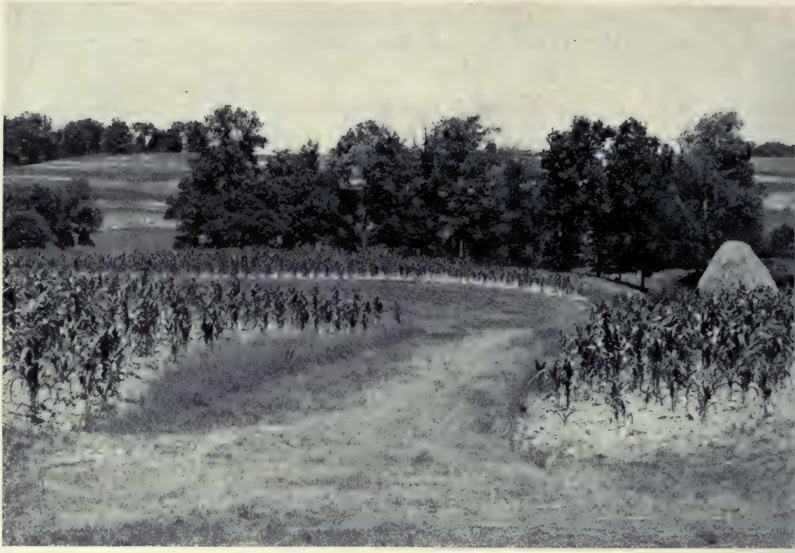


FIGURE 13.—This waterway is kept permanently in grass. Hay is harvested from the waterway the same time that it is removed from the meadow strips that alternate with the corn strips.

Terracing

Considered as a single method of soil-saving strategy, terracing probably been the most widely tested. Various types have been in use for hundreds years in the Orient, Central America, parts of Europe, and many other countri In our own country, after the one-crop cotton system marched across Southern States, leaving the land open and "bleeding," farmers there, desperation, developed our first earth embankments to hold soil. Handicapp by inexperience and the lack of appropriate tools and adequate power for use their construction, many of these early builders constructed terraces that fail to hold the soil. Yet withal, we can thank these southern farmers for develo ing the highly effective broad-base type of terrace, which serves so well the South and are now being used also in the North and West.

Despite the most recent improvements, terraces must be supplemented by s improvement and other control measures. With the exception of permane grass and tree covers, no single control measure, terracing included, is adequa to hold soil. Terracing, experience has proved, should be combined with cr rotations, strip cropping, and other measures that are most appropriate for given field. The success of one control method must rely upon the success the others employed. Frequently good farm-management practices and a go cropping system will fail without the support given by mechanical measur Likewise a mechanical measure, like terracing, is almost sure to fail without t support of contour farming, an appropriate cropping system, and soil treatme

Terraces alone cannot be expected to hold soil against the punishing abuse of row crops under continuous cultivation.

On land adapted to their use in the Northeast and on watersheds within project areas of the Soil Conservation Service modern broad-base terraces are now under trial in widely scattered areas. They can now be found in the intensive potato-producing section of Aroostook County, Maine, in the rich general-farming sections of Pennsylvania and Maryland, and in the more level coastal plains of southern New Jersey (fig. 14).

Terraces as applied to farm land for erosion control are surface-drainage channels at appropriate intervals across the slope. The upper side of the embankment forms a channel that intercepts the flow of water as it moves down the slope. Terraces are given a slight fall, which permits the accumulated surplus water to move slowly, and therefore safely, off the field to the terrace outlet. The terrace system, in effect, breaks the original long slope of a field into a series of short slopes, and short slopes permit less erosion than do longer ones.

Generally it is unwise to rely upon terraces for protection of fields devoted to cultivated crops, where the slopes are more than 12 percent (a 12-foot drop for each 100 feet in distance). So much depends upon the absorptive capacity of the soil, farming methods, and the crops grown that rule-of-thumb figures are useless. If slopes steeper than 12 percent are terraced, it frequently requires considerable effort and expense to maintain the ridges at the proper height and to keep the channels clear. When excessively steep slopes are terraced there may be some erosion between the terraces even if the best of cropping and cultural practices are followed.

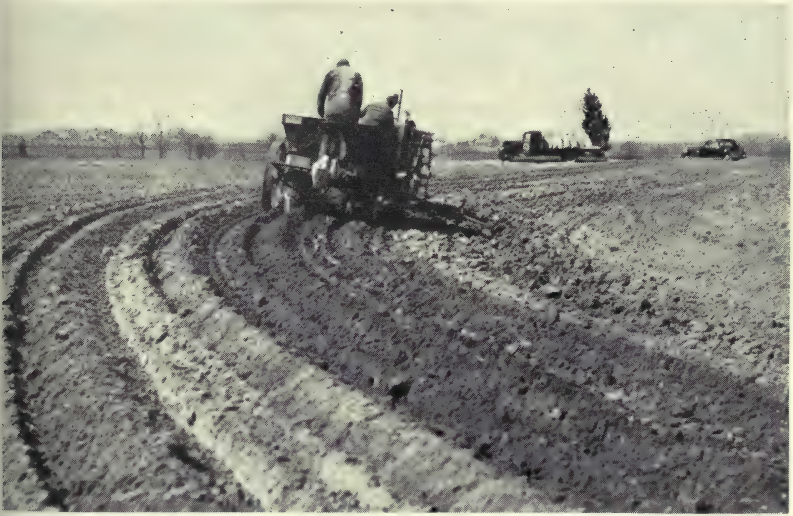


FIGURE 14.—Planting potatoes on a terraced field in New Jersey. Note that the rows are parallel to the terrace.

Grades and Spacing

In general, terraces in the Northeast are given a slight grade, and this grade is usually variable. The grade should seldom exceed 5 inches in each 100 feet. Starting with a zero grade at the upper end, the grade is generally increased one-tenth inch per 100 feet, at 300- to 400-foot intervals throughout the length of the terrace toward the outlet. Terraces without grade are occasionally used in permanent hayfields, pastures, and orchards.

The slope of a field is the principal factor governing the spacing of terraces; yet the soil type, extent of erosion, and the rainfall must all be considered. The spacings indicated in table 1, based on the original investigations of C. E. Ramser and more recent results obtained at conservation experiment stations, may be used as a general guide in determining the spacing on different slopes.

TABLE 1.—*Terrace spacings on land of different slopes*

Item	Terrace spacing on slopes per 100 feet of—				
	2 feet	4 feet	6 feet	8 feet	10 feet
	Feet	*Feet*	*Feet*	*Feet*	*Feet*
Vertical fall between terraces	2¾	3½	4	4¾	5½
Distance between terraces	137	88	67	59	55

The Outlets

In building terraces in the early days, many farmers gave scant attention to the disposal of water after it left the terrace channel. Water has been discharged upon steep slopes, into small narrow ditches, along roadsides, and onto areas inadequately protected by sod. This oversight has frequently led to the ruin of more land than the terraces have saved. No terrace system is complete until satisfactory means have been provided to ease excess water safely to the natural drainage channels (fig. 15). Even though outlets have been properly designed and constructed they must be given attention year after year. Small repairs must be made promptly; otherwise more costly and larger reparations will be required later.

From many standpoints it is desirable to construct outlets and get vegetation started at least a year before the terraces are actually built on the field. This permits sod to become firmly established and reduces the likelihood of early damage by washing. If this is not done, it may be necessary to divert the water temporarily, thus giving vegetation a better opportunity to take hold. These vegetated outlets should have flat bottoms from 8 to 20 feet wide, depending on the drainage area and slope. The wide bottoms spread the water and thus reduce the speed and the cutting action. The detailed design and the proper location of terrace outlets are important problems; for this reason competent engineering advice should be obtained before construction work is started.

Occasionally the topography of a particular field or the absence of convenient tlets outside the field itself may make it necessary to prepare outlets on the ld. These outlets should be prepared in advance of terrace construction.

Mechanical structures of masonry or concrete are sometimes necessary if equate vegetative protection cannot be obtained. If these structures are quired, the grade between structures from notch to apron must be level. ovision must be made for adequate openings for water flow, ample cut-offs, d head walls to avert overtopping, cutting around ends, or undermining. ther details of construction are of prime importance. Since poor planning, a fective design, or an effort to effect a slight economy by using inferior materials y lead to failure, it is of the utmost importance that competent engineering vice be sought. The cost of materials is slight in comparison with labor costs.

URE 15.—This terrace outlet provides for the disposal of water falling on the field shown on pp. 36–37.

he initial expenditure for a properly constructed terrace system can be quickly t if improper tillage practices are followed and needed repairs are not promptly de. Small breaks in the terrace ridge after each heavy rain may be quickly paired with a shovel or a slip scraper drawn by a team. These minor repairs especially important during the first year when the ridges are settling. Small llies starting in the outlet may be effectively and quickly checked by sodding. eaks or leaks around the permanent structures should be filled and tamped; herwise the damage will become more serious with each heavy rain.

n some areas of the Northeast, because of the steepness of slopes and the atively shallow depth of soil, terracing as practiced in other parts of the country may never find such widespread adoption. There are, however, many area within this region where the soil, slope, climate, and the intensive type of agriculture followed abundantly justify the protecting arms and additional suppor that terraces might give. These areas frequently have a high valuation per acre and on them the cost of producing agricultural products is high. Althoug terracing requires a cash outlay, no farmer who has land adapted to terracin should hesitate to incur the expense if terraces will help protect his origina investment in the soil and his annual investment in fertilizing materials.

Diversion Terraces

A somewhat modified form of a terrace system, called the diversion terrace o diversion ditch, is receiving praise from many farmers who have land that is no well-adapted for a complete terracing system. This is true particularly in th dairy and general-farming areas of New York, Pennsylvania, Maryland, easter Ohio, and West Virginia. As a general rule, grass in these areas remains longe in the rotation than it does, for example, in the more intensive cash-crop areas Aroostook County, Maine, the trucking areas of New Jersey, or the tobacc section of southern Maryland. However, on some of the longer slopes wher water converges in greater quantities, and where the cropping area lies below large drainage area, the diversion terrace offers a helping hand to the vegetativ control.

On areas of this type where the cropland is usually found in valley floors an edges onto the steeper slopes, followed in turn by pasture and the woodlan still higher up, covering the top of the hill, the diversion terrace is found to b especially useful. Just below the pasture field, soil conservationists place diversion terrace to prevent water from running down over the cultivated area The cultivated land below the diversion terrace will be strip-cropped on th contour. If the slope in the cultivated area is long, additional diversion terrace will be placed between the cultivated strips.

When diversion terraces are constructed on cultivated land in connection wit strip cropping the area immediately above the terrace must be placed in permanent sod. This grass cover catches and holds any silt that might be washe from a cultivated strip into terrace channels. Unless this is done the silt liable to form dams in the channel and cause the ultimate failure of the ditc At the present time agronomists and engineers feel that this grass cover shoul be not less than 40 feet wide and wider if possible. Effort should be made t increase the fertility of this strip, thus making the cover more effective.

Diversion terraces or diversion ditches are similar to terraces (fig. 16). The are usually given more capacity than a standard terrace because they handl greater quantities of water. They may be narrower at the base and higher a the crown than the standard terrace, but they must be broad enough and lov

GURE 16.—A diversion terrace in a West Virginia field. Note the grass strip above the channel.

iough so that grass can be mowed easily. Like the standard terrace, the diveron terrace is never used unless a suitable natural outlet can be found or one n be built at a reasonable cost. Diversion terraces have been used on slopes up to 30 percent, whereas the standard terrace is seldom used on slopes of ove 12 percent.

Pastures

Pasture is a crop. Yet, the pasture on most farms receives only "stepchild" nsideration in comparison with other crops. Productive pastures (fig. 17) otect the soil on a farm in two ways: (1) The thick sward is ideal protection ainst erosion; and (2) the increased income made possible by the higher carryg capacity makes it less necessary to provide additional supplemental feed om cultivated land.

In recent years exhaustive studies relating to the pasture problem have been ade by both Federal and State experiment stations. Better practices worked it as a result of these studies have been demonstrated, and the information ined has been made available to farmers through the various State colleges d extension services. As a consequence, one can find numerous examples in e Northeast where a pasture infested with poverty grass and devil's paintush and carrying one cow on 3 or 4 acres has been made to profitably carry much as one cow to the acre.

In general, pastures usually become unproductive because of depleted fertility lack of available moisture during droughty periods or because they have been nproperly grazed.

Except on certain soil types, which are comparatively rare, potash is usually present in sufficient quantities to promote the growth of desirable grasses and legumes On the other hand, there is practically never sufficient nitrogen and phosphoru in available form to permit the best growth of pasture plants. Since nitrogen ca best be supplied through legumes, like wild white clover, this element is provide when other deficiencies are remedied. An application of lime may be necessar to get the clover started. Phosphorus and lime are the master keys to the solution of the fertility problem on the vast majority of pastures in the Northeast

Many of these pastures were formerly areas under cultivation which becam unprofitable because of depleted fertility. Under grain farming the drain on th phosphorus supply is especially heavy.

On pastures that have never been under cultivation the deficiency of phosphorus may not be serious; yet even pastures that have not been plowed fo many years may show a deficiency of phosphorus, owing to its removal throug animal and milk products sold from the farm.

To correct the phosphorus deficiency, college and experiment station worker generally recommend an initial application of 300 to 600 pounds of 20-percen superphosphate per acre. This initial application is usually followed every 3 o 4 years with a top dressing of 300 to 400 pounds of superphosphate. These applications, if accompanied with proper grazing management, maintain the pastur on a productive basis. After the initial lime requirement is met, additional ap

Figure 17.—Good pasture is both a crop and a soil conserver. Erosion control alone frequentl justifies the cost of pasture improvement.

plications are necessary every 6 to 10 years in order to maintain the lime requirement. In most cases and on average pastures when lime and fertility requirements are satisfied, reseeding is unnecessary.

Some of the changes to be expected in a treated pasture are: Increased growth of white clover, spreading in all directions; the crowding out of devil's-paintbrush, poverty grass, and other undesirable species; the appearances of valuable grasses such as Kentucky and Canada bluegrass, bentgrass, and perhaps others; increased absorption of water by the soil, and resulting denser cover that provides protection against run-off water.

Pasture Furrows

More than a hundred years ago Thomas Jefferson, splashing in leather boots as he walked over his beloved Monticello after heavy rains, observed that contour furrows conserved water and that this additional water could be retained for the benefit of plants. The contour-furrow method has been used widely in the Southeastern States on cultivated land, but more recently it has been successfully applied on sloping pasture fields.

On practically all projects of the Soil Conservation Service and in areas where members of C. C. C. camps have been assigned to erosion-control work, pasture furrows are now on trial under a wide variety of conditions (fig. 18). After heavy rains technicians, equipped with foot rules and soil augers, have made numerous tests to see how deeply moisture has penetrated. They have found

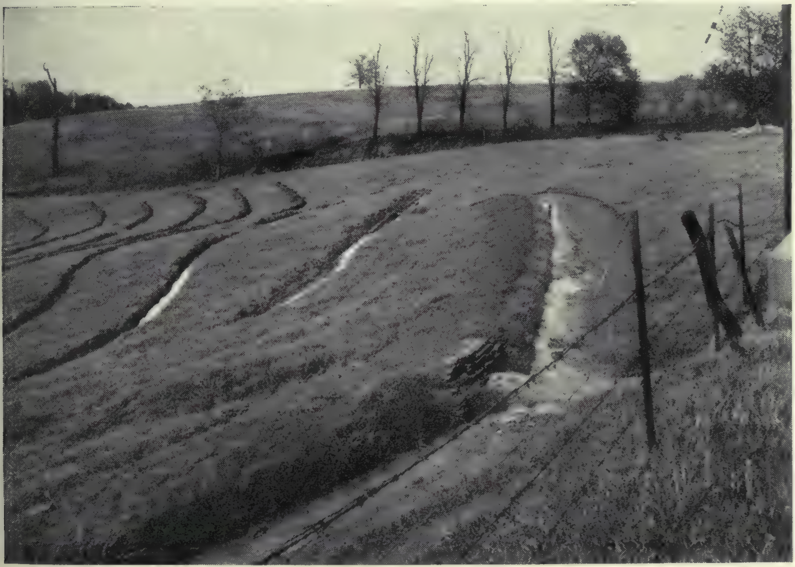


FIGURE 18.—Pasture furrows on a Pennsylvania hillside. Note the water standing in the furrows and the arrangement to spread water as it flows from the road culvert at the right.

that the moisture has frequently gone from 6 to 18 inches deeper on land that i furrowed than on similar land without furrows. Frequently as much as 80 per cent of a heavy rain can be held on furrowed land.

Pasture furrows are level, and they are usually constructed with an ordinar breaking plow (fig. 19). Machines are now being tested, however, which ar designed to construct furrows in such a way that the existing vegetation wil be disturbed as little as possible. Spacing between the furrows depends upo the steepness of slope, the cover, the soil, and other factors. Usually they ar spaced at about 1- to 2-foot vertical intervals; this places the furrow from 6 t 15 feet apart, depending on the slope.

It is necessary that grass be established on the ridges and furrows as quickl as possible to prevent washing from the heavier rains that might overtop th ridges. The furrow slice is prepared by harrowing and dragging, and lime fertilizer, and manure are usually added when the ridges are seeded to haste the growth of vegetation.

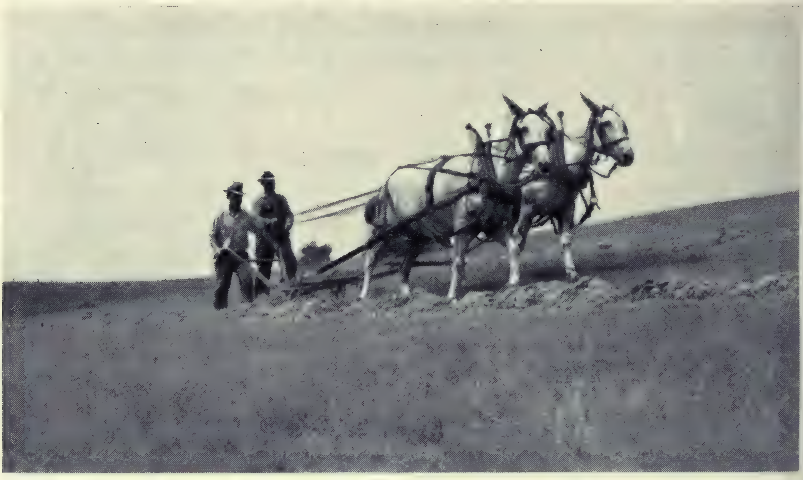


FIGURE 19.—Contour furrows in pastures are usually constructed with an ordinary breaking plow.

Trees

Trees have demonstrated their usefulness as soil and water conservers. In their use on project areas of the Soil Conservation Service two objectives are sought. One is to make new plantings of trees wherever they will aid in con serving soil, whether in a gully, along a fence row, or a part of an entirely new planting on land that has been converted from pasture or cultivation. The other objective is to give trees, in the present woodlands, such care and atten tion that they will continue to serve as soil conservers and yield a maximum income in lumber, fence posts, or fuel.

New Plantings

Except on gully-scarred areas, all new plantings of trees are made on the contour. Usually, but not always, these plantings are made in contour furrows. The furrows are made with an ordinary breaking plow and are usually spaced about 6 feet apart. The furrows help to hold additional moisture for the benefit of the young trees. Under some conditions the furrows may be a detriment. If they are not on the true contour, the impounded water may start a new gully farther down the slope. To reduce this hazard small earth dams are frequently placed across the furrows at about 100-foot intervals. Again, if the seedlings are planted in the bottom of the furrow, as they frequently are, they may have a poorer type of soil in which to grow, as the surface soil has been turned out by the plow.

In general, trees are planted about 6 feet apart each way. Normally, mixed plantings—conifers and hardwoods—are preferred. Among the advantages claimed by foresters for the mixed plantings are: The resulting leaf litter and decaying roots increase the permeability and water-holding capacity of the soil; they promote greater activity of organisms in the soil; and they provide better cover for wildlife. Furthermore, with mixed plantings, disease or insect attacks are not likely to be serious.

The ordinary plantings in the project areas in the Northeast include the following: Red, white, pitch, and Virginia pines, oaks, black locust, sugar maple, and white ash. These species are varied somewhat in accordance with the availability of planting stock and the local conditions encountered.

Black locust trees in the young forest play a role similar to clovers in a field-crop rotation. The locust tree is a legume and gathers its own nitrogen from the air. The experiment stations have called attention to the beneficial effects of black locust on other tree species. When grown together—that is, black locust and other hardwoods—there is a notable increase of growth in the other hardwoods as compared with the growth of the same species some distance away.

Since the conifers listed retain their foliage during the entire year they offer greater protection as windbreaks and shelterbelts than the hardwoods, and under average conditions they give the maximum degree of protection to the soil, and provide much-needed winter cover for wildlife.

Woodland Management

Returns from the farm woods, as is true with other crops grown, are generally in proportion to the care and management given by the owner. In this bulletin we are concerned primarily with the care of the woodland because of the permanent protection which an adequate forest cover gives to the land and to wildlife. If the woodland is made to contribute its share of profit it has a better chance of receiving continuous care and attention.

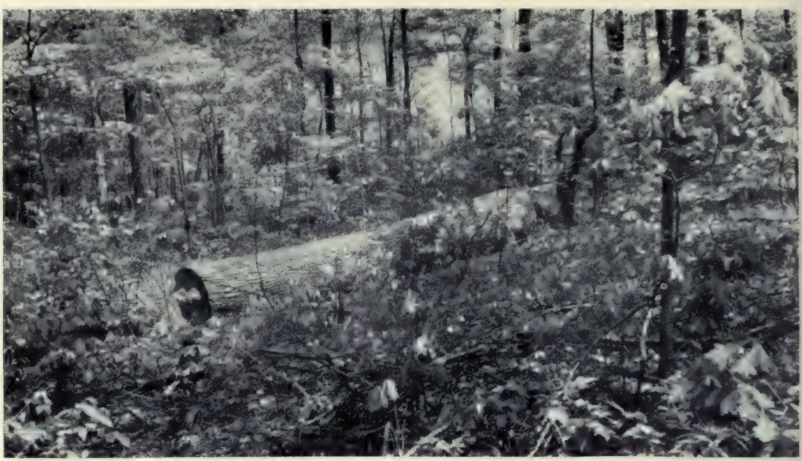


Figure 20.—This mature white oak tree has just been cut. Selective cutting of mature trees has been practiced in this ungrazed farm woods for several years. The soil is well protected against erosion.

If vegetation and leaf litter on the forest floor are disturbed or destroyed by fire or grazing, the soil no longer has a maximum protection. Fires frequently destroy or damage much valuable timber and the ground cover, as well as the habitat for wildlife. Under intensive grazing, the soil becomes packed and impervious to water because of trampling; the undergrowth is destroyed or impaired; weed trees are given a chance to come in; and reproduction is damaged by trampling. Controlled experiments have shown that cattle actually lose weight when confined to woodlands. Continued grazing means eventual destruction of the woodland. It follows then that one of the first steps in woodland management is the control of the archenemies of the forest—fire and overgrazing.

Farmers who become cooperators with the Soil Conservation Service in the improvement of their woodlands have two goals in view. One is to increase the proportion of the marketable species of trees, and the other is to develop a system of harvesting that gives the best returns consistent with sustained production and the conservation of water, soil, and wildlife (fig. 20). Precise methods to be used in attaining these goals vary with the conditions found in each wood lot, the soil, and market outlets. Complete information on woodlot management may be obtained from State and Federal agricultural agencies.

Gully Control

Gullies in the Northeast are so few in comparison with those in other regions that they do not shout ruin to every passerby. Extensive areas in grass and trees account in part for their absence. Then, too, bedrock or a tough impervious shale lies so near the surface in many areas that moving water can scour soil particles loose but slowly.

Up to now little has been said about treating gullies for the reason that it is wiser to remove the conditions that caused the gullies before attempting to mend the gullies themselves. Furthermore, many gullies that are now active may become stabilized naturally if control practices are placed in effect on the higher land which feeds them (fig. 21). Some gullies may become stabilized if livestock is excluded by fencing and natural revegetation thus permitted.

The aim in all gully-control work is to give vegetation an opportunity eventually to reclaim the area and make further repairs unnecessary. In treating most gullies the biggest problem is to keep water out of the channel until vegetation becomes established. Frequently it may be necessary temporarily to divert water away from the head of the gully. In preparing the area for vegetation it is often necessary to smooth down the rough banks and in the same operation place some of the better soil on the gully floor. The larger gullies may become stabilized more quickly if temporary check dams of earth, brush, native rock, and other materials are installed. After temporary check dams have been installed the whole area must be planted to trees, shrubs, vines, or grass, or a combination of these. Suitable trees probably should always be included in the selection. The plants chosen, both woody and herbaceous, should whenever possible, be selected for their value as food and cover for wildlife.

Occasionally the proximity of buildings or the value of the land may warrant the expense of costly concrete and masonry structures. When this is the case it is always desirable, if not absolutely necessary, to obtain competent engineering advice before expense is incurred.

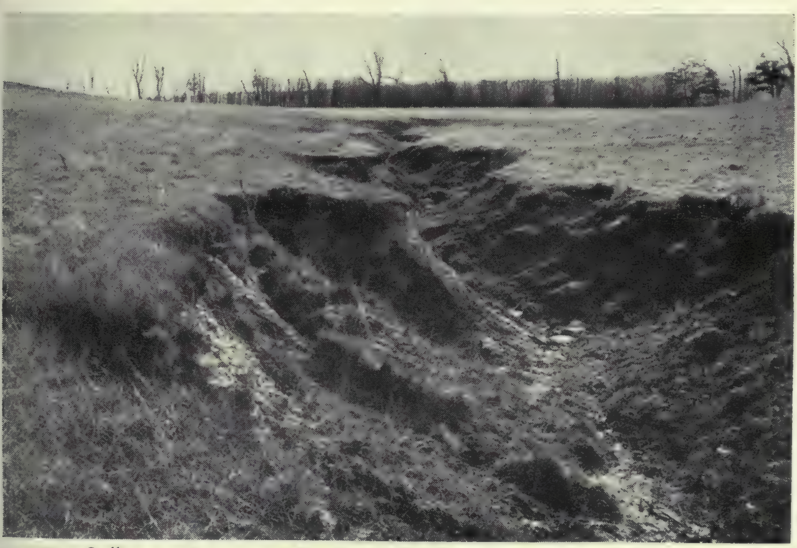
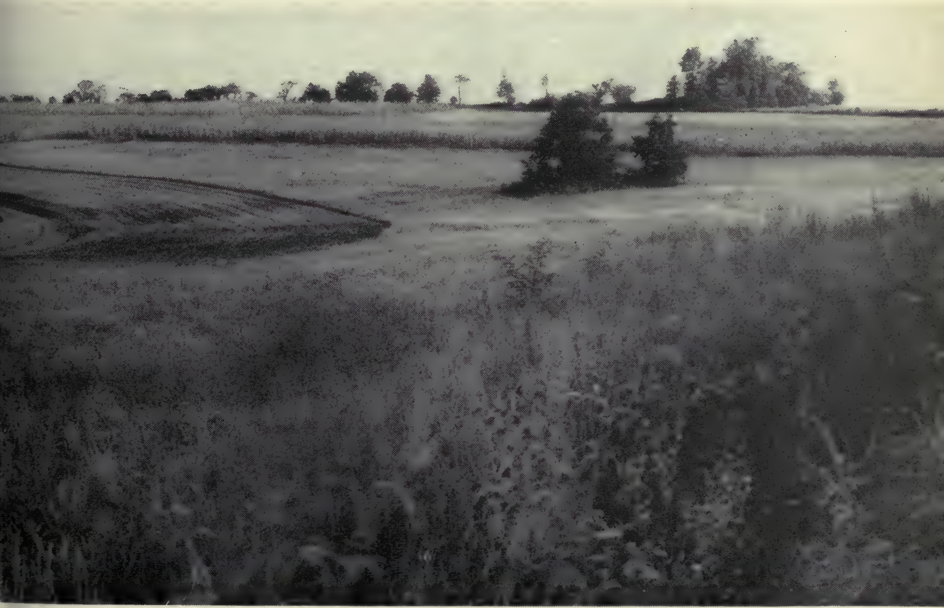


FIGURE 21.—Gullies may become stabilized naturally if the vegetation on the watershed which lies above is improved.

The picture above shows the principal farming land on a Lancaster County, Pa., farm prior to the development of methods to control erosion. Stakes have been set to determine boundary lines for strips on the contour. Prior to the adoption of erosion-control practices the lay-out of these fields has always remained in a rectangular pattern.

In the picture below we see the altered pattern of field lay-out, two diversion terraces, and crops growing in strips across the slope on the contour. The diversion terraces, which total 1,870 feet in length, are provided with a protected outlet that safely conducts excess water to the natural channel at the extreme left. See figure 15.



Wildlife Plantings

Wildlife species can survive and multiply only when there is sufficient cover and food available (fig. 22). Erosion control and the needs of wildlife can be served in the same planting. In the planting of gully banks, farm-road banks, stream banks, the corners and sides of eroded fields, diversion-ditch outlets or spreaders, and other small odd-shaped areas wherever found, conservationists keep an eye on the needs of wildlife. In the larger areas which are devoted to new plantings of desirable trees, margins of food-producing shrubs and vines are used. Around the margin of woodland, an "edge" planting of woody vegetation will provide food and cover where most of the wildlife congregates.

Among the more common woody species which are being used in the Northeast with wildlife needs in mind are: Gray dogwood, hackberry, scrub oak, persimmon, blackhaw, American hazelnut, mapleleaf viburnum, wild plum, coralberry, bittersweet, Virginia creeper, black chokeberry, Japanese barberry, silky cornel, flowering dogwood, red-osier dogwood, thorn apple, lowbush honeysuckle, winterberry, Hall Japanese honeysuckle, wild crab apple, red mulberry, bayberry, Norway spruce, red pine, pitch pine, white pine, Virginia pine, black cherry, chokecherry, white oak, northern red oak, wild rose, American elder, European mountain-ash, snowberry, northern white cedar, hobblebush, withe rod, arrowwood, nannyberry, highbush cranberry, wild grape, and bush lespedeza.

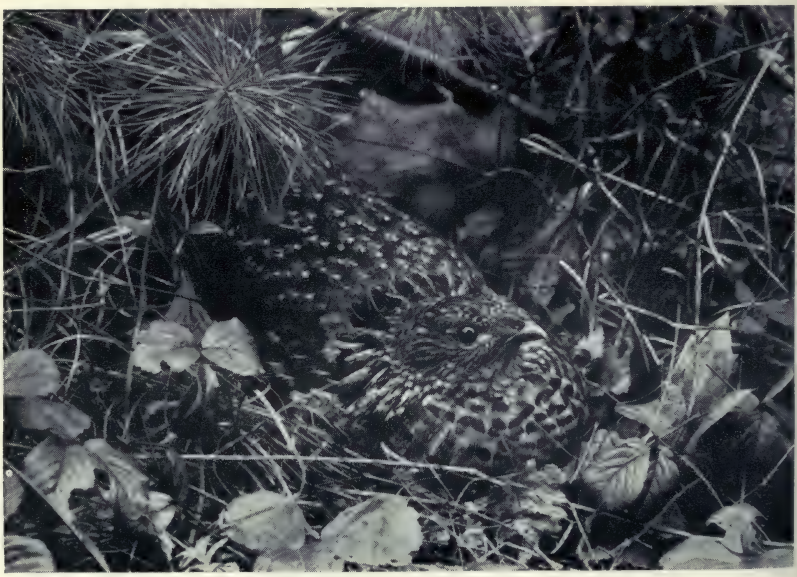


Figure 22.—This ruffed grouse is well provided with natural cover.

Outposts of Cooperative Defense

IN LOOKING BACK over our agricultural record, two facts stand out boldly: (1) We have underestimated or ignored the rate of topsoil removal and the accompanying loss through erosion, and (2) we have overestimated, if we recognized any erosion at all, the value of single defense measures.

Recognition of these facts led directly to the establishment of the project areas which are located on soils repreentative of large agricultural regions. These project areas, selected with the advice and approval of officials representing the experiment stations, the extension services, and the colleges of agriculture, are designed to demonstrate the appropriate combination of control practices adapted to the area and to individual farms within the area.

Granting that a farmer is aware of losses caused by erosion, it is no exaggeration to say that nowhere, until the last few years, could he see how modern soil-husbandry methods could be applied in their most effective combination to his own land. A farmer in the Northeast could, for example, have taken a trip into the Southern States to see the improved broad-base terrace. He could have visited the few communities in Ohio, West Virginia, and Pennsylvania where strip cropping has been employed for many years. But nowhere could he have found the coordinated application of these and other practices upon farms similar to his own.

In the Northeast, as elsewhere in the Nation, whole watersheds are usually selected for the project demonstration areas. These areas vary in size from about 18,000 acres, at Moorestown, N. J., to 150,000 acres, at Bath, N. Y. Once an area is selected, each farmer is given an opportunity to cooperate with the Government and his neighbors in the development of control measures on his own farm. Prior to the making of any extensive plans a careful survey is made on all farms of cooperating owners to determine the extent of erosion, the past use of the land, the slope of the fields, and the characteristics of the soil.

The survey results, when assembled and interpreted, provide the basis for a control program. This program is presented to farmers; those who are sufficiently interested, agree to follow definite control practices on their own farms for 5 years. The Soil Conservation Service, in turn, agrees to provide technical and a limited amount of material assistance in carrying out the program.

It must not be assumed that these programs for individual farms were hastily agreed upon. Accompanied by the farmer, technicians walked over each and every field, and they mutually decided upon a course of action. They considered cash-crop requirements and the needs for forage and pasture. The soil, steepness, and length of slope, the climate, the markets, and other factors were carefully noted. The rotations best adapted to meet these requirements were discussed and agreed upon. Plans were made for the erection of new fences and the relocation or removal of old ones so that fields could be farmed on the contour. The use of diversion ditches in connection with strip cropping and for the protection of pasture and cropland was discussed. Wood lots were to be protected against stock. Pasture treatments were planned. Severely eroded areas were to be devoted to trees or grass. In brief, each farm plan was drawn to make effective use of modern soil- and water-saving practices and at the same time to give the farmer as large an income as he had previously received, or larger.

The preceding section described the various practices, both old and new, which are now being used to curb losses induced by erosion. This section tells how these practices are now being employed by farmers cooperating with the Soil Conservation Service under conditions that apply to six different project areas. Space limitations will not permit the discussion of each of the 14 projects (see map on back cover) which are now established in the Northeast. Neither will it be possible to discuss the work being done by C. C. C. boys in camps that are attached to several of the project-demonstration areas.

Ohio—The Owl Creek Area

A line run southward from Sandusky, Ohio, on Lake Erie, would roughly mark the divide between the agriculture of the Northeast and the Middle West. To the west the Corn Belt stretches; to the east clamber the low rolling foothills of the western Appalachian Mountains. West of the line where the land flattens in Ohio, soils have been formed largely from limestone. East of that line, soils have been built principally from shales and sandstone.

The richer and more level limestone soils to the west encouraged continuous cropping, and a more speculative type of agriculture on the whole, than the more diversified farming of eastern hill farmers. Many older people now living on these undulating slopes speak of the land to the west, that may be less than an hour away by auto, as the "Plains." Merchants in border-line towns, who draw trade from both the hills and the Plains, often argue the relative merits of the two groups of farmers with whom they deal. Plains farmers more frequently ask for credit, the merchants say, than the hill farmers do.

Just east of this imaginary line, in Knox and Morrow Counties, the Soil Conservation Service has established one of its projects. It is designated as Ohio 4. This 30,500-acre strip lies between Granny and Dry Creeks, which orm its upper and lower boundary lines. Both creeks flow eastward into the Kokosing River (better known as Owl Creek). Project headquarters is at Mount Vernon, the county seat of Knox County, on Owl Creek.

The few white men who entered this central Ohio wilderness in the last decade of the Eighteenth Century found that Johnny Appleseed Chapman, s was his custom, had planted apple trees in small clearings, in anticipation of heir arrival. In an abandoned Indian field on the banks of Owl Creek, Chapman established one of his many small nurseries. But apart from these small learings the whole area was thickly wooded.

When settlers in greater numbers arrived they seem to have been troubled s much by wolves as by Indians. In 1805 settlers in the "Jersey" settlement nding wolves "plenty and impudent," agreed "to give 9 bushels of corn for ach wolf scalp that might be taken" and as a result "3 of the men caught 41 wolves in steel traps and pens." Deer, though not apparently troublesome, were numerous. A report of a "circular" drive, starting on the banks of Owl Creek in 1818, indicates that "from 300 to 500 deer and many wolves were agged." In that early time a man, it is said, could step just outside his cabin oor and shoot a week's supply of game.

The early settlers may not have been "water conscious" in the sense that we se the term today; yet water played an important role in their lives. Many f them arrived by boat, and when dams were built the streams provided power o grind their grain and to saw their logs. This area in Ohio was regarded as specially favorable by mill owners due to the "durability" of the streams. Yet as early as 1881 N. N. Hill, Jr., in his History of Knox County, said:

> * * * mill streams are not what they once were * * * steam is taking the place of water ower. The fact is, that since timber has been cleared away and the swamps drained, the olume of water has been greatly lessened, and streams became * * * very insignificant.

Corn and wheat were the most important crops grown in this section following the removal of timber from the land. By 1880 an unmistakable trend toward more livestock was apparent. The increase in livestock was coincident with the ultivation of new soil beyond the Mississippi. More livestock on the farms nd an increasing number of horses in towns and cities caused more hay and ats to be grown.

By 1900 the agriculture of the district was fairly well diversified, but further djustments were soon to be made. Automobiles and tractors came, and the market for horse feed dwindled. During the World War grain growing was widely resumed, but this was soon followed by an expansion in dairying, due o the prospering industrial cities and better transportation facilities.

Livestock has been increased during recent years out of proportion to the arrying capacity of pastures. Because of excessive grazing and lack of management, pastures have declined rapidly in productiveness and in their ability to protect the soil against erosion. Many of these pastures are so thin that not more than 50 percent of the soil is covered with vegetation. In an effort to increase the carrying capacity of these pastures, many of which lie on the steepest slopes, farmers have plowed and reseeded in the hope of bringing them back to productiveness. These efforts usually failed, and erosion losses increased. Furthermore the demand for pasture caused many farmers to turn their cows into woodlands where there was little forage but where much damage was done to the woods. Moreover, cropping and erosion have exhausted the fields in rotated crops to such an extent that forage crops, particularly legumes, are not being produced in sufficient quantity to feed the cattle. As a result the pasture field gates are opened too early in the spring to livestock and they are closed too late in the fall.

Practically all of the cropland and pasture land in this project area needs an application of lime. The subsoil at a depth of 4 feet or more contains plenty of lime, but this is out of the reach of most farm-crop plants. Most of the soil to a depth of 4 feet is definitely acid.

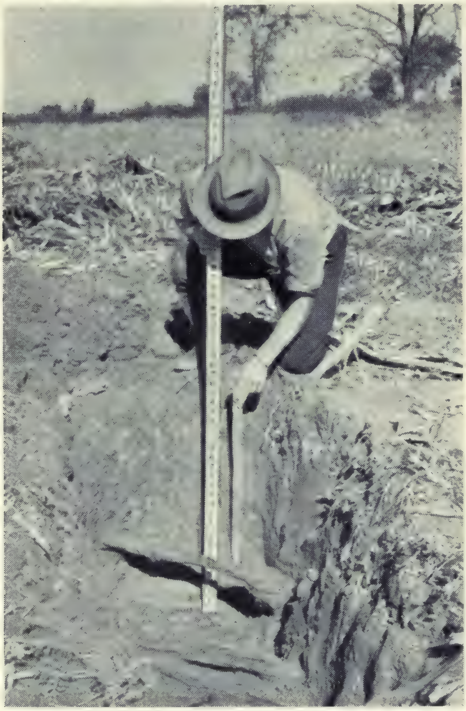


FIGURE 23.—In 1892 a sawmill stood at this spot in Knox County, Ohio. Today, almost 2 feet of topsoil covers the remains of an old slab pile. Soil was washed here from a field having a 3-percent slope.

The typical downward spiral of declining crop yields is well illustrated in this area. Farmers here started with a soil that was low in lime. Despite applications of phosphorus in commercial form and more than the average amount of manure, clover failures became more and more common owing to the absence of available lime. When clover seedings failed, the fields were usually plowed and planted to corn. Checkrow corn planters were generally used, which meant that practically every square foot of soil on these irregular sloping fields was cultivated up and down the hill. Clover was again seeded in the wheat which followed the corn, but the chances for success in obtaining a catch decreased year by year. With clover failing, the soil became less absorptive of rain ater, thus causing an increased amount of run-off and soil loss. When drought me there was insufficient moisture stored in the soil to produce profitable crops.

Erosion surveyors examined the surface soil in this area in the fall of 1935 and und that approximately 40 percent of the area has lost between 25 and 50 rcent of the topsoil by sheet wash (fig. 23). Another 15 percent has lost tween 50 and 75 percent, and over 75 percent of the topsoil has been lost about 2 percent of the area. While the soil surveyors found gullies on arly 7 percent of the area, most of them were so shallow that few farmers d difficulty in crossing them with machinery.

GURE 24.—The lengthening of crop rotations and strip cropping are among the major control measures being used by farmers in this project area.

Defense measures in use on the Granny and Dry Creek project represent for e most part a concerted application of proven devices to hold soil. Land too eep or too severely eroded to support an adequate grass cover is converted to a farm woods. Farm woodlands in turn are protected from livestock, and y open spots are planted to trees. Steep slopes in cultivated fields are seeded a permanent meadow or pasture. Though most of the slopes in the area are t extremely long or steep, their unevenness and irregularity make strip cropping fficult to apply on many farms (fig. 24). Strips are used wherever possible, owever, and farming operations are on the contour wherever practical (fig. 25).

Practically every farmer in the area has been attempting to follow a 3-year tation consisting of corn, wheat, and clover or timothy. Since clover failures ave been numerous the rotation, in actual practice, frequently is not of more an 2 years' duration.

The improved rotation on all of the rolling land calls for 2 or 3 years of meadow stead of 1, thus providing a 4- or 5-year interval between periods of cultivaon. Yet lime seemed to be the key to the success of this rotation. All the pland soils require from 1½ to 3½ tons per acre to insure clover. When the roject was started only four lime distributors could be found in the entire area, and it is estimated that less than 5 percent of the farmers had ever used lime While most of the farmers had been applying superphosphate for a number years in small quantities it was apparent that larger applications were necessary Furthermore, recent tests of 300 soil samples by the Ohio State University ind cate that the available potash supply is too limited for the best plant growth.

Three steps are being taken in this area to improve the pastures. One ste is to restore a portion of the lost fertility by applying at least 1½ tons of groun limestone per acre and at least 300 pounds of 20-percent superphosphate. Anothe step is to place furrows on the contour to catch and hold rain water for the bene fit of vegetation. And still another step provides for better grazing managemen

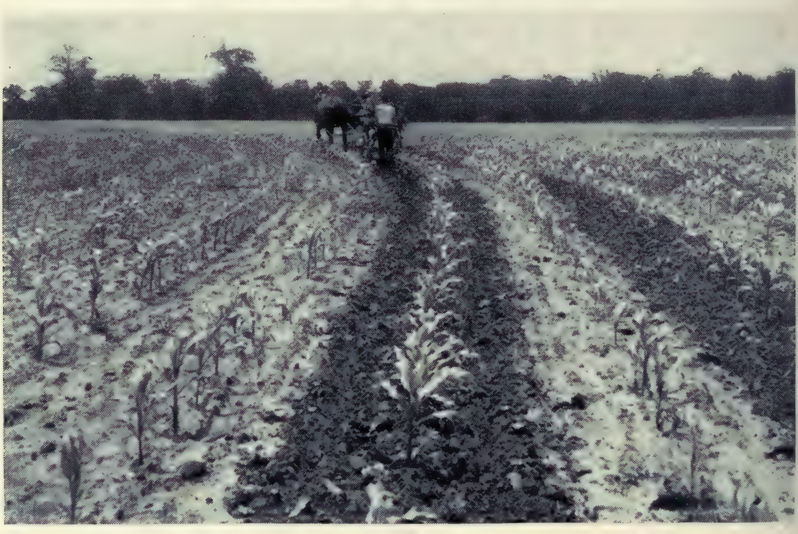


FIGURE 25.—These Ohio farm boys are having their first experience in cultivating corn on t contour.

Although soil- and water-saving operations did not start in this area until th spring of 1936, 102 farmers in two seasons made changes in practices and use their land as shown in table 2.

TABLE 2.—*Practices adopted and changes in land use during 1936–37*

Land treatment	1936	1937
	Acres	*Acres*
Land cultivated on the contour	None	9
Cultivated land under strip cropping	do	5
Contour furrows on pasture land	do	
Pasture land limed	Very little	4
Pasture land treated with fertilizer	do	3
Lime applied on cultivated land	do	7
Heavier than normal application of fertilizer on cropland	do	7
Woods fenced against livestock	do	9
Longer rotations used than in 1935		4,9

Between midnight June 20, 1937, and the evening of June 21 rain gages indicated that 3 inches of water fell on the Granny-Dry Creek area. Every creek and river in the area overflowed, and the result was severe loss of crops in the owlands. Farmers on these lowlands said the water was at least a foot higher than during the flood of the preceding January.

The next morning, June 22, technicians of the Soil Conservation Service and many farmers hastened out over the land to see whether the defense measures had been effective in holding the soil. One farmer said he was not pleased with his crooked strips until after this hard rain. Another said:

> I'm well satisfied with the way the strips kept my soil from washing. If the whole field had been n corn this year it would have been full of gullies.

Another said:

> I walked over my neighbor's field where he had planted corn up and down the slope. There was a lot of soil lost between each row and the ground was hard. If you will just walk out across my strips you will see the ground is still soft.

West Virginia—The Moundsville Area

George Washington explored the upper reaches of the Ohio River in October and November 1770. He started at the point where Pittsburgh now stands and mapped his course down the river, indicating distances with plus and numeral signs at 4-mile intervals. Thus on his chart, we find +72, +76, +80, and so on to +112. His "+92" is marked just below the site now occupied by Wheeling and the "+100" appears where Moundsville now stands. This chart is reproduced in the Moundsville Echo (centennial edition) August 1935. The distances from Pittsburgh are incredibly accurate as comparison with the closely calculated river maps of today shows.

A skilled surveyor, with a keen eye for good land, Washington laid claim to Round Bottom, a West Virginia 587-acre tract (later reported as 1,293 acres) enclosed in a wide sweeping and almost circular bend of the river. This "round bottom" which appealed to Washington, and another flat area a few miles up the river, now occupied by Moundsville, lie at the western edge of the soil conservation project area which comprises 28,975 acres of land drained by Middle Grave Creek and Little Grave Creek. These two flat areas next to the river include nearly all of the level land that can be found in this part of the country.

About 1775 settlers first cleared the more gentle slopes adjacent to the river. Soon, however, demands from the down-river markets for flour and whisky induced the clearing of land all the way up to and over the hilltops, which tower 500 to 700 feet above the river. On these hills—many of them sloping over 40 feet for each 100 in distance—corn, wheat, and rye were grown for eager buyers at the river front.

In the beginning these hillside soils rewarded the pioneer with abundant crops, but the yields were too good to last indefinitely. As early as 1840 wheat yields dropped to about 10 bushels per acre, whereas a 35-bushel yield had not been uncommon at the beginning of the century or earlier. As a result of excessive cropping and erosion, abandoned farms dotted these West Virginia hills before the prairie sod of Iowa was broken.

Within 10 years after the decline of grain farming, sheep began to appear on many of the steeper hills that were formerly under cultivation. The fine-wool sheep industry increased intensively until about 1890, as it also did over a large section of southeastern Ohio, the Panhandle of West Virginia, and southwestern Pennsylvania. An industrial boom in the Ohio Valley about 1900 caused the sheep industry to give way in part to more diversified farming; cattle raising and dairy farming appeared; truck crops came in; and practically all of the few remaining stands of saw timber were removed. Sheep, however, are still numerous. Marshall County, where the project area is located, has more sheep than any other West Virginia county. And these sheep—between 30,000 and 40,000 of them every year in Marshall County—along with cattle and dairy products, account, on an average, for about 65 percent of the cash receipts.

With the exception of the World War period, when plows again opened these slopes, the general trend in the area for 30 years has been a retreat from cultivated crops to grass and to trees. Part of this adjustment has been enforced through declining prices. Another, and perhaps a still greater part, has been due to awareness of the hazard of continuous cultivation on the steeper slopes.

A survey of 150 farms, completed in May 1937, showed that 60 percent of the crops were grown on slopes that fall less than 25 feet in 100. Only 1,022 acres in the entire project of 28,975 acres lies on slopes of 5 percent or less, and only 963 acres lies on slopes tilting between 5 and 15 percent. While 7,876 acres was found to be on slopes of between 15 and 25 percent, the bulk of the acreage, 17,405 acres, or 60 percent of the entire area, lies on slopes of 25 percent or more.

In most areas of the Northeast one looks up the slope to see erosion; here in Marshall County, one looks down. With but few exceptions, the narrow pinched valleys scarcely permit elbowroom, to say nothing of the requirements for roads and buildings (fig. 26). Consequently one finds houses, barns, gardens, and most of the cultivated land up and over the hilltops, while pasture and trees are far below.

When erosion surveyors examined the soil in this area in 1936 to determine the extent of losses through erosion they found it difficult to locate any spots where trees had not been removed. The depth of the topsoil on land that had been disturbed the least by cultivation and grazing indicated that the original surface soil had been 6 to 8 inches in depth. When these determinations were compared with surface-soil depths on cultivated land, pasture lands, and grazed woodlands, it was estimated that from 2 to 4 inches of soil had been washed from 14,366 acres, or nearly half the land in the area. On 8,246 acres it was estimated that to 6 inches of soil was lost. Only 1,987 acres could be classified under the erm "slight erosion," which means a loss of 2 inches or less of surface soil. On he remaining 2,648 acres it was found that all of the surface soil and part of the ubsoil had been removed.

Soil losses, as estimated above, indicate clearly that soil is being lost much aster in the Moundsville area than it is being conserved under present farming onditions or rebuilt under natural processes. Even with the abandonment of arms and the reluctance of many good farmers to plow the steeper slopes, resent safeguards are inadequate to stop soil losses.

IGURE 26.—In the Moundsville area cropland is usually found on the top of the hills, while pasture and woodlands are in the narrow valleys.

The first step in developing erosion-control practices in the Moundsville area vith farmers in 1936, was to get the farmers to assign more of the cultivated rops to land on gentler slopes. This was no easy task in view of the fact, as lready stated, that 60 percent of the cropland now occupies slopes of 25 percent r less. In general, slopes of 25 to 40 percent were assigned to pasture and those f more than 40 percent to woods.

The prevailing rotation of crops in the area, at the time project activities were tarted, was corn, oats, wheat, and grass. In this rotation, cornfields were usu-lly left bare during the winter and spring months, thus permitting severe rosion. A few farmers left wheat out of the rotation and seeded their grass nixture in the oats. There has been little success in securing good grass stands n oats, and this method is not commonly used. Perhaps the chief objections to he prevailing crop rotation from the standpoint of erosion are the lack of a cover rop following corn and the fact that most farmers leave their meadow fields in rass so many years that there is little sod to turn down when the field is plowed.

The improved cropping plan, which is now in effect on most of the farms wher soil-saving practices are employed, calls for corn, wheat, and 2 years of meadow When alfalfa is included in the meadow seedings, as it frequently is, the rotatio is lengthened to 5 or 6 years. Oats, which are seldom a profitable crop in thi area, have been generally dropped from the rotation. Since wheat follows corn i the rotation none of the land is left bare during the fall, winter, and spring month Along with the improved cropping plan, fertilizer and lime treatments are recom mended to insure that the rotation can be maintained on a profitable basis.

Strip cropping is used on practically every farm where erosion-control practice are employed. The steep slopes make it necessary to provide as narrow strips a are consistent with practical operations on the farm (fig. 26). The corn strips ar usually one shock row in width. If corn is drilled in rows 42 inches wide thi would give a shock row 42 feet in width. Occasionally a strip may contain tw shock rows of corn, making the width 84 feet if the slope of the land will permi the additional width.

Diversion terraces, which now total over 15 miles in length, are used as a com panion measure of control in conjunction with strip cropping. A few diversio terraces have been constructed in pasture fields.

Tree planting in this area, aside from the requirements for gully control, i usually considered from the standpoint of giving protection against erosio Most of the trees have been planted in 30- to 50-foot bands on the steep breaks c pasture slopes. Black locust and black walnut are being used for this purpos It is well recognized that bluegrass does well in association with black locust an it grows fairly well under black walnut.

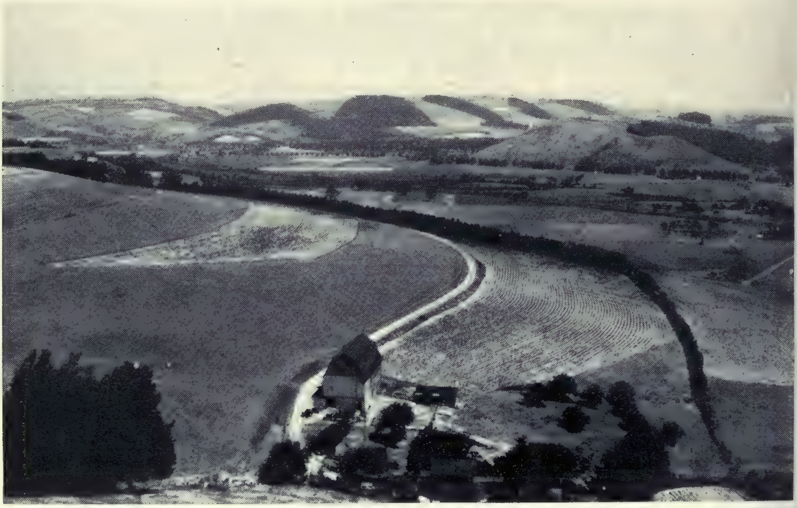


FIGURE 27.—Valley floors comprise about 20 percent of the land area in the Cohocton River wate shed.

The steep V-shaped gullies, frequently having a bottom that is a foot or less ı width, require a special method of planting to insure stability. Woody vegeıtion, consisting of various species of close-growing shrubs and vines, is planted n the banks and along the top. All of these plants, it will be noted, serve the ouble purpose of stabilizing the gully and at the same time providing food and ɔver for wildlife.

Check dams are used in some of the gullies to assist in diverting water from the hannel to a grassy area.

Pasture is the basis for the livestock industry. Yet many pastures are so badly roded and unproductive that they provide an insufficient amount of feed. The ırvey of 150 farms mentioned earlier indicates that 50 to 60 percent of the pasıres are capable of carrying only one animal to 6 or 8 acres. Fertilizing with 400 ounds of 20-percent superphosphate an acre and applying lime when needed, long with contour furrowing, controlled grazing, and mowing, are the principal teps taken to improve the pastures.

Although soil- and water-saving practices were not started in this area until 936, some of the major changes effected in 2 years' time are shown in the followıg tabulation:

hanges in land use:	*Acres*
Cultivated area retired to permanent pasture	962
Cultivated area retired to permanent pasture and woods	309
Cultivated area retired to permanent meadow	523
Fences and other obstructions removed to permit strip cropping	185
Area strip-cropped for the first time	2,369
Pastures treated with lime and fertilizer	969
Pastures furrowed	118

New York—The Cohocton River Area

The East's largest soil- and water-conservation project is located in southvestern New York. It includes the upper watershed of the Cohocton River. 'he waters of the Cohocton flow in a southeasterly direction to the Chemung nd thence to the Susquehanna. A great majority of the 150,000 acres included ı this watershed lie in Steuben County. Approximately 10,000 acres lie in ivingston County and a few are in Yates and Ontario Counties. Headquarters ɔr the project are at Bath.

A network of valleys, which are seldom more than 1½ miles wide, traverse the rea in a northwesterly and southeasterly direction. The comparatively rich ɔil of the valley floors invites intensive cultivation. The uplands, comprising he long slopes and the plateaus, which tower in many places from 700 to 900 eet above the river bed, account for about 80 percent of the land area (fig. 27).

Glacial drift, of variable thickness, covers this plateau section. The surface ıantle of soil is underlain with beds of shale and sandstone. The hill soils are derived from noncalcareous glacial till, whereas the valley soils have been buil chiefly from glacial outwash and post-glacial alluvium. Much of the till o perhaps 50 percent of the land area is open, friable, and well-drained, bu some of it is underlain with a compact hardpan layer. Due to this variation i the character of the subsoil, there is a wide difference among the various soil in regard to moisture penetration and absorption.

Forests once covered the entire watershed; but, apart from a few swamps practically all of the land had been cleared and brought under cultivation som time during the last 150 years. While trees have reclaimed perhaps 20 percen of the area in more recent years, the cover has frequently been impaired b fire, pasturing, and improper cutting. Some fields formerly in cultivation ar now either idle or are used for pasture.

Steuben County was once the banner potato-growing county of the East And, although potato production has steadily decreased since 1909, this cro in cash value, still leads all others in the watershed. The deep, well-draine soils on high elevation are well-adapted to potatoes and give yields that ar well above the national average. For the 3 years 1929, 1930, and 1931 th hill soils yielded an average of 154 bushels an acre. Farmers who use commercia fertilizers and other improved practices frequently produce yields of more tha 225 bushels an acre.

In more recent years dairy cows have come into the area to help maintain th income that was formerly derived chiefly from potatoes. Since dairy cow require large quantities of forage and pasture, this shift has been beneficia from the standpoint of erosion.

The acreage of crops in the typical rotation—potatoes or corn, oats, clover and timothy—is not more than 35 percent of the total land acreage. Unques tionably a larger acreage devoted to crops in rotation would induce more erosion

When clover catches fail, as they frequently do, or when the land become depleted through cropping so that potatoes cannot be grown profitably, man farmers resort to buckwheat for a cash crop. This crop, along with potatoes accounts for the most serious erosion on the cultivated land. Corn, it is uni versally admitted, permits severe erosion, but the crop in this area is usuall planted on the more level bottom lands and the acreage allotted is less than tha for buckwheat.

Even though the total acreage of potatoes, buckwheat, and corn—three crop that permit severe erosion—is small in this area and there is a diversity of farm enterprises, the natural conditions impose unusual precautions. Slopes are steep About 57 percent of the land has slopes varying between 5 and 25 percent About 17 percent of the area has slopes varying between 25 and 35 percent Eleven percent of the land area has slopes of over 35 percent. Usually about 53 percent of the annual rainfall comes between May and September, inclusive Usually two or three of the summer rains are of severe intensity. When rains ıch as these fall on the long steep slopes—slopes that are from three-quarters) a mile in length—soil and water losses may be severe.

When surveyors examined the topsoil on 70,722 acres in this area they found rosion apparent on all but 8.5 percent of the land area. On 34 percent of the ınd they found that up to 25 percent of the surface soil had been removed by rosion and on 42 percent of the area that from one-fourth to three-fourths of ıe topsoil had been removed. Fifteen percent of the land area showed losses f 75 percent or more of the topsoil.

In formulating a basis for erosion control on the various farms in the area, chnicians of the Soil Conservation Service developed a plan of land classification based on the degree of slope. Generally on the well-drained soils sloping ss than 5 percent it was thought that no protective measures would be needed. lopes of from 5 to 25 percent could be safely cultivated if adequate protection as given; slopes of between 25 and 35 percent required grass or trees, and opes of more than 35 percent could safely be planted in trees only.

One of the urgent problems in the area was to find desirable cover crops to ccupy the land after potatoes and buckwheat had been harvested. Smooth ıd Russet Rural types of potatoes are normally grown. These varieties maıre so late in the fall that rye cannot be sown early enough to attain sufficient rowth for adequate cover. A few farmers in the project area have planted a art of their crop to early-maturing varieties such as Chippewa and Katahdin. hese varieties can normally be harvested early enough so that rye seeded nmediately afterwards can make sufficient growth for protection. Moreover, ıis plan aids in the distribution of labor. The plan is still on trial, but the sults to date warrant a wider adoption of the practice.

No crop grown in the area leaves the soil so loose and vulnerable to erosion does buckwheat (fig. 28). Like potatoes, the crop is harvested late in the ıll, thus giving no opportunity for a cover crop to develop sufficiently to revent soil losses if the crop is seeded after the buckwheat is harvested.

The seeding of rye with buckwheat is a plan under trial. About 1 bushel of uckwheat to 1½ or 2 bushels of rye is seeded per acre, the usual rate of seeding each crop were to be grown separately. If the crop receives favorable rains uring the few weeks prior to the buckwheat harvest the rye survives well ıd by winter may reach a height of 6 to 8 inches. The following year ıe crop may be plowed down as green manure or allowed to mature as rain.

Farmers in the Bath project area tread on a narrow safety zone when using me. If too much lime is used, the potatoes are likely to be scabby. If no me is used, clover failures become more and more common, as practically all ɔils in the project must have lime to insure success in obtaining clover. In cent years some farmers have applied too much lime, and their results have nded to discredit its use in more moderate amounts. It is clear now that lime in a quantity sufficient to grow red clover can be applied without harmfu results.

To make it possible to convert the steeper slopes now in cultivation to per manent grass, it was apparent at the outset that if the farm income was to b maintained or increased, more dependence must be placed upon the hay cro in the rotation. And to make the hay crop successful, legumes must be grow in greater quantities. This invariably means the use of lime and phosphorus Local deposits of marl have been made available to farmers in the area. Th Soil Conservation Service has demonstrated methods of excavation and success ful spreading of the marl which offers considerable promise as a satisfactor local source of lime. This marl has from 85 to 95 percent of total carbonates

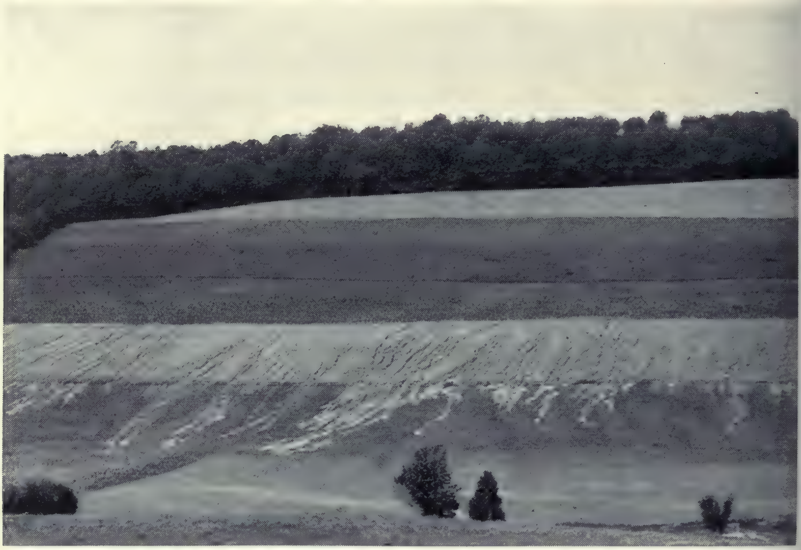


FIGURE 28.—Buckwheat and potatoes are two crops that permit severe erosion in the Cohocto River area. The picture above shows a poor arrangement of strips. Buckwheat was plante immediately below the strip of potatoes. One rain did most of this damage.

Practically all of the pasture land in the area needs treatment to secure sward that will provide protection against erosion and more feed for livestock Each step in the pasture-improvement program is directed toward the reestab lishment of wild white clover. Lime is applied in sufficient quantity to permi the growth of red clover. Phosphorus equivalent to 800 pounds of 16-percen superphosphate is applied to each acre. After 4 or 5 years lime and phosphoru are again applied as needed. Rotation grazing and the clipping of weeds ar equally important features in the improvement of these pastures. Methods o improvement have been demonstrated on approximately 1,060 acres o pasture land. Farmers on land adjoining the project have applied these prac ces on many times this number of acres. Contour furrowing of pasture land is der trial. It is not yet known whether contour furrows will increase the rrying capacity of a pasture sufficiently to warrant their general use. It is elieved, however, they have a real place on the pastures with the poorest vards, where every aid is needed in alleviating drought conditions, and par-cularly on slopes with a southern exposure.

Contour farming as an erosion-control practice appealed to many farmers from e beginning. This was the case, perhaps, because many farmers have en accustomed to plowing and cultivating across the slopes. However, most f this cultivation across the slopes has not been close enough to the contour to event soil loss.

Strip cropping has proved to be one of the major practices adaptable to the strict. When strips were laid off on many of the farms in 1935, a few farmers ere reluctant to have them follow the contour as closely as recommended. hey believed, at the time, that the variable width of the strips and the crooked ws would make farming operations difficult. Strips on the true contour, they arned, after one season's trial, were much more effective than those in the laying t of which considerable deviation was permitted. As a result many of these rmers in 1937 requested that every strip boundary be placed on the absolute ntour even at the sacrifice of an even-width strip. By February 1, 1938, ,630 acres had been planned for strip cropping, which included two-thirds of l the rotated cropland on the farms operated by cooperating farmers. Most f the remaining one-third was on gently rolling or flat land which did not need e protection that strip cropping offers.

Diversion terraces may almost be considered a companion measure to strip opping as a method of preventing soil loss in this area. This type of structure as been found to be especially useful in preventing water from the poorly ained upland soils from running down over well-drained land devoted to strip ops. On long slopes, several of these terraces may be constructed in connection ith strip cropping in order to break the slope and reduce the large concentra-ons of water. These structures are designed to handle the water from rains of aximum intensity, which may be expected to occur about once in 10 years. lthough engineers and agronomists believe there are refinements and improve-ents yet to be made in the diversion terraces, their usefulness has been proved this area. In 1935, 749 lineal feet of diversion terrace structures were built on e project, and by 1937 there were 80,468 feet in operation. The drought of 936, and the resulting loss of many seedings on outlets, made it necessary to sod any spots in the spring of 1937.

Farm woods comprise approximately one-fifth of the project area. With iso-ted exceptions the farm woods have declined in their usefulness as soil con-rvers. In general, this decline has been caused by unwise management, such grazing and injudicious cutting for fuel and lumber. With the cover impaired on the woodlands, which lie, for the most part, on the steepest slopes—many on slopes of more than 50 percent—an increasing amount of water rushes from these formerly well-protected areas and frequently flows down over pasture and cultivated fields to the detriment of both.

On 204 farms improvement plots have been laid off to demonstrate the proper methods of selection and cutting (fig. 29). These plots total 512 acres and are located in farm woods that total 5,304 acres.

Approximately 7,000 acres of farm woods are now protected from grazing livestock. These lands were unprotected prior to the establishment of the project area in 1935.

Tree planting on the slopes to be retired from pasture or cultivated lands has been confined principally to the following species: Red pine, Norway spruce black locust, white pine, and red oak. During the 2-year period 1936–37 trees were planted on 2,526.3 acres and on 298 farms Extreme drought conditions during 1936 made it necessary to replant many trees the following year. Including the newly planted acreage of trees and that of the farm woods protected from grazing, there are now approximately 10,000 acres of woodland on a substantial basis of control.

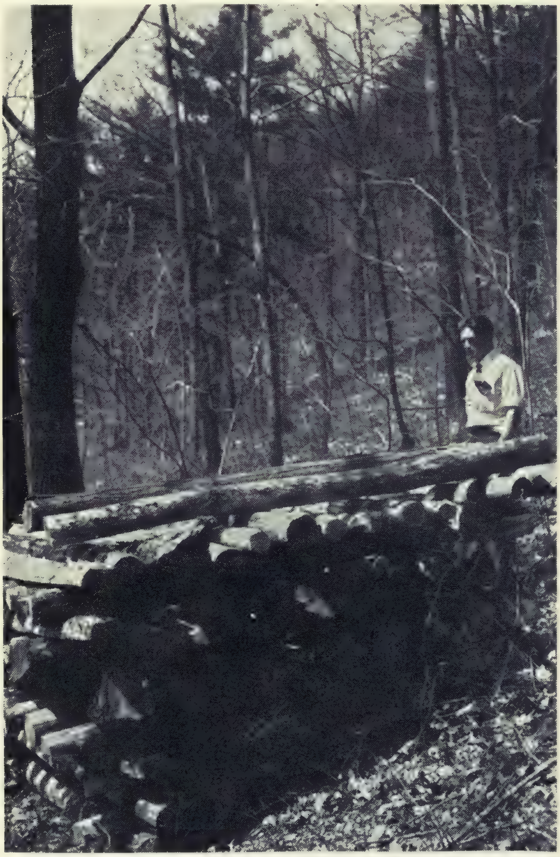


Figure 29.—Selective cutting of timber has been demonstrated on plots which total 512 acres. These plots are located in farm woods that total 5,304 acres.

Although the project has been in operation only 2 years, 307 farmers are working out a complete program of soil and water defense for their land. These 307 farmers operate 39,514 acres, and 21,058 of these acres are now under treatment with erosion-control practices. Treatment has been completed on 15,750 acres.

Pennsylvania—The Lancaster Area

One of the Northeast's most extensive belts of soil developed over limestone vings down across southeastern Pennsylvania and northern Maryland. It osses the Potomac in the vicinity of Harpers Ferry, where the mouth of the enandoah marks the northern extremity of Virginia's famous valley. During e first flush of settlement, about 1700, the Germans, the Swiss, the Scotch-ish, the Welsh, and the English swept over this limestone pathway. All were clined to seek land similar to that which they knew most intimately in the Old orld. Influenced by an ancient aversion to "dry" limestone lands, many of the st comers, particularly the Scotch-Irish, later sold out to Germans and went on. hey preferred the slaty hills where they found pure springs of water near the rface.

The first of the Germans went no farther than the limestone lands of Penn's omain which appeared so similar to those of their homeland in the Rhine alley. And they looked with particular favor upon a somewhat detached and alf-hidden limestone zone in York and Lancaster Counties.

This area early gained a reputation for its productivity. And later, when the lonists were engaged in the Revolution, it was to this area and other sections arby that Washington looked for the salvation of the patriot's cause. On ay 28, 1780, to Joseph Reed, he wrote: "Either Pennsylvania must give us all e aid we ask of her or we can undertake nothing * * * the fate of these ates hangs upon it."

After approximately 200 years of continuous occupation by the white man is area probably is in as high a state of preservation as any long-established ricultural section on the continent. Part of this preservation can be attributed the natural productive capacity of the soil, part to the permanency and skill of e management, and part perhaps to the diversity of products made possible y the diversity of markets.

Though soil losses have not yet caused general concern in Lancaster County ere is ample evidence that damage occurs every year on some of the most prouctive soils. Water from one heavy rain during the summer of 1937 washed any tons of soil onto the Old Philadelphia Pike 8 miles east of Lancaster. his soil was carried through a newly etched gully in a clover field that lies on 3-percent slope. But back of the clover field, on this particular watershed, 80 res had been planted to corn, and much of the silt originated there.

Though most of the soils in Lancaster County originated from limestone, the ils in the project area were derived chiefly from gneiss, schist, and quartzite. his project lies in the watershed of West Octoraro Creek. The summary of e erosion survey indicates that 86 percent of the area has been affected by heet erosion; 73 percent has lost more than one-fourth of the topsoil; and 14 ercent of the area suffers from gully erosion in various stages of development.

On the whole, and through the years, there has been a fair balance betwee the cropland and the land devoted to pasture and timber. Farms in the are today contain an approximate average of 115 acres per farm. These 115 acre are apportioned approximately as follows: Woods 15; pasture 15; cropped lan 80; and roads, buildings, and farmsteads 5. Yet on these 80 acres of croppe land only 35 are normally devoted to corn, potatoes, tobacco, and other intertille crops. Moreover, practically all of the corn and oats and much of the wheat i fed to livestock on the farm. Manure applied to the land has helped to maintai fertility and resistance against the wash of rains.

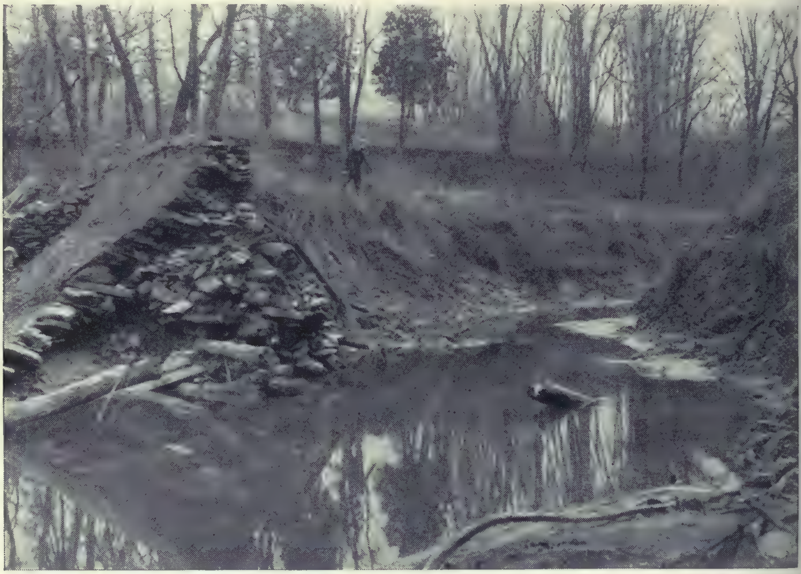


Figure 30.—When this dam was destroyed by heavy rains in 1934 the water washed out a V-shaped channel into a deposit of silt 11 feet deep.

Though these soils have received better than average care, judged by prevail ing standards, natural conditions in the area impose severe handicaps. The lan elevation varies from a low of 240 feet above sea level to a high of 920 feet above The average rainfall of 42 inches annually, 30 of which falls during the growin season, on these slopes make it necessary to provide additional safeguards t prevent soil loss.

The dams of many abandoned mills which were formerly driven by wate power reveal losses of soil from the watersheds above them. Kings Mill, o Kings Run, was built more than a century ago. In 1934 water from heavy rain washed out the dam above the mill. Water pouring through the break, etche out a V-shaped channel into a deposit of silt 11 feet deep (fig. 30). This silt wa piled to the very brink of the old spillway. The richest soil in the deposit

ngineers found when examining the channel, lay at the bottom, while soil
earer the top was poorer and more sandy. The engineers calculated that this
nall dam, through the years, had backed up approximately 27,000 tons of top-
oil. The V-shaped cut alone accounted for some 7,250 tons of soil. Of the 1,200
cres in this small watershed, approximately 75 percent is cultivated farm land.

The crop rotation generally practiced in the project area includes corn the
rst year. In the second year, tobacco, silage corn, tomatoes, or another culti-
ated crop may be grown. In the fall of the second year wheat is usually seeded,
nd this crop is followed by 1 or 2 years of hay. Occasionally wheat may follow
heat a second year.

Much of the erosion on the steeper cropland can be attributed to the use of
wo cultivated crops in succession and the fact that no cover crop has been
rown following the first crop of corn. To improve this rotation, from the
andpoint of erosion control, a few farmers cooperating in the project, are now
eding biennial sweetclover after the last cultivation of corn or rye after the
orn is harvested. If the slope is very steep the rotation is shortened to include
ut 1 year of a cultivated crop. Combinations of the various common grasses
e on trial as cover crops for seeding at the last cultivation of corn. The
rimary purpose is to provide a cover that is resistant to erosion. A secondary
onsideration is the amount of organic matter produced for turning under.

Since much of the wheat is sown after corn has been cut, it frequently does not
tain sufficient growth to resist erosion. Service cooperators are making an
fort to get the wheat seeded earlier. Timothy sown in the fall improves the
over during winter. Legumes seeded in the spring further enhance the ef-
ctiveness of the cover. Winter barley rather than wheat is being sown the
cond year of small grains by some farmers. This crop normally produces a
ery good cover before freezing weather.

In addition to the soil losses mentioned above as being caused by two inter-
lled crops in succession, perhaps the next most serious losses in the past have
een caused by plowing a whole sloping field and growing an intertilled crop.
trip cropping effectively checks the loss in these fields, and many farmers believe
at by its use they have received higher crop yields because of the increased
nount of moisture which was available during droughty periods in the growing
ason. On farms under agreement, with slopes of 6 to 15 percent, strips of
ıltivated crops are now protected with alternate strips of wheat or hay.
trips are normally about 100 feet wide, although on a few farms where the
opes are more gentle they may be as much as 125 feet in width. By February 1,
938, 2,220 acres in the project area had been planned for strip cropping. (See
lustration in the center of bulletin.)

On fields under cultivation that slope less than 12 percent the standard broad-
ase terrace (fig. 14) has been found useful. These structures, which total 23
iles in length, are now in operation on 14 farms. Diversion terraces have been

found beneficial on cultivated slopes of from 12 to 30 percent. These structures now in operation on 20 farms, are built with a terracing outfit and are usuall spaced from 200 to 400 feet apart; the average spacing being about 300 feet. O July 5, 1937, over 4 inches of rain fell in 22 hours. This was the first sever storm, locally referred to as the "big rain," which tested both the terraces an the diversion terraces.

Treatment of pastures in the area usually involves one or more of the following steps: Applications of lime and phosphorus; contour furrowing; mowing o weeds; and controlled grazing. To date 41 acres of pasture on 10 farms hav been contour-furrowed.

Treatment of woodlands involves the fencing out of livestock, the planting o small steep areas that were formerly in cultivation or pasture, and the selectiv cutting of timber to afford a sustained yield of lumber, fuel, and fence posts.

Practically all of the soils (Chester, Manor, Edgemont) in the project area wer low in lime in their virgin condition. Through the years, leaching, cropping, an erosion have further reduced the supply to such an extent that lime must b applied on many fields to insure an adequate growth of legumes. Limestone o high quality (97 to 99 percent of total carbonates) can be found in the county although much of this is not readily accessible to farmers in the project area The Soil Conservation Service has demonstrated how some of the lime of lowe quality (80 percent total carbonates), which is more accessible, can be prepare economically for local use. If a particular field needs an application of 2 tons o the lime of average quality, 2½ tons of the lower quality lime is recommended.

New Jersey—The Pensauken Creek Area

One of the three New Jersey soil and water conservation projects lies just eas of Camden and is in sight of the higher buildings in Philadelphia. Approximately 80 percent of the project area is in Burlington County and 20 percent is i Camden County. Where the northern boundary of the area crosses the Pensauken Creek the land elevation is about 10 feet above tidewater. From this leve it rises to a general elevation of 70 to 100 feet.

Except for villages and wet land along streams which have been left in timbe the area of 17,980 acres is in farms, of which 12,672 acres are used for cropping purposes; the rest being in pasture, woodland, and idle land. About 48 percent o the acreage, 8,676 acres, is devoted to tomatoes, peppers, cabbage, melons, an various other vegetables. One-fifth of the area is devoted to fruit, principall apples and peaches.

In the days of the horse, New York, Philadelphia, and other cities on the easter seaboard used steam-drawn scows and flat cars to remove manure from the city t the land (figs. 31 and 32). South New Jersey Coastal Plain vegetable and frui growers could pay good prices for this manure, and most of it came to their land

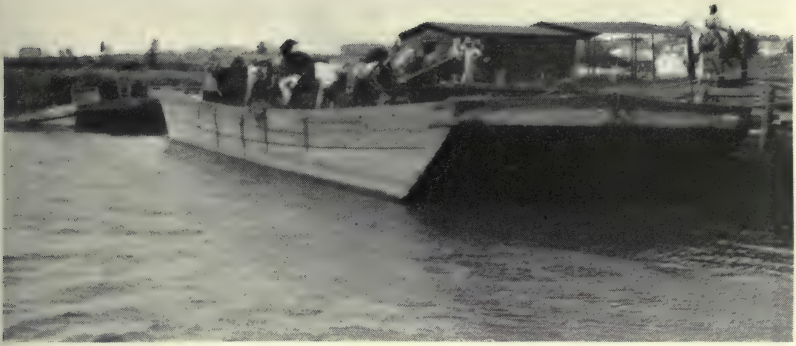


Figure 31.—Unloading manure from a scow in 1912.

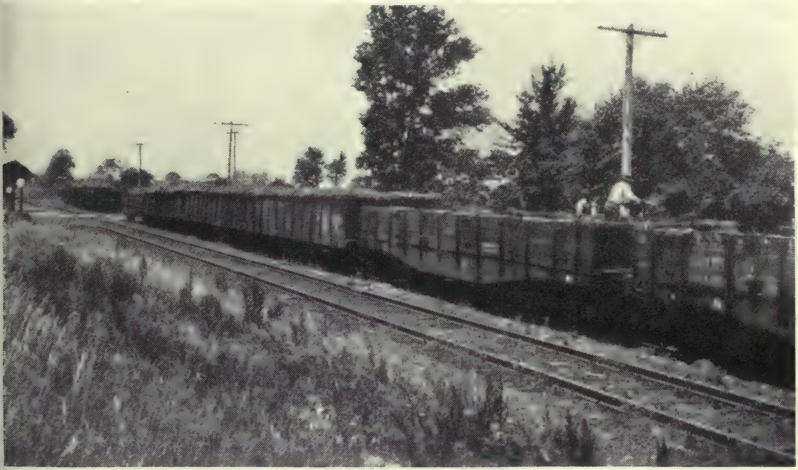


Figure 32.—Unloading manure from the streets of New York City, on the Coastal Plain of New Jersey.

When motor vehicles so largely replaced the horse, Coastal Plain soils were leprived of this source of natural replenishment. Since that time vegetable and ruit growers have relied chiefly on plant food from commercial sources. But the rganic matter, which makes manure most valuable, has not been available in ommercial form at a price farmers can pay. Furthermore, the general exodus of he horse from the cities all but destroyed the market for hay, with the result that rass appears very infrequently in the rotation of crops.

Realizing their need for organic matter, many farmers in late years have sown all cover crops to partially replace the supply that was once available from the ity. But the intense cropping system imposed by high land valuations, and the lack of livestock to consume forage crops made it impossible to maintain the organic matter in sufficient quantity. Paradoxically, it seemed that the farmer could not afford to grow his organic matter, and neither could he afford to be without it.

Most of the soils on this Coastal Plain area are sandy loams or loamy sands. These soils require large quantities of organic matter to knit them together and make them more absorptive to rain. Moreover, organic matter tends to disappear more rapidly than in most soils owing to the intense cultivation and heavy applications of fertilizer. Many farmers use winter cover crops to help maintain the supply of organic matter. The cover crop, however, is usually poor, because of the late plowing of the land in the fall and early plowing in the spring. Many of the vegetable crops leave small residues, and in some cases both the roots and leaves of such crops are sold, as with carrots and beets.

Because of the inadequate humus content of the soil; because of a type of farming—double cropping in many cases—that leaves the soil bare to the elements for a greater part of the year, and because of the light texture of the soil, it is not uncommon to find severe cases of erosion where the land slopes 3 feet or less in 100 feet of distance. Farmers have stood out in pouring rains with technicians of the Soil Conservation Service and watched soil moving off spinach fields onto strawberry plants in a field with slope that is barely perceptible.

The casual observer or one who expects to find erosion losses only on land with a decided slope may pass this Coastal Plain section by with unconcern. Yet when soil surveyors mapped this project area and examined the depth of surface soil they estimated that losses ranged from zero to 25 percent on 73 percent of the land. And they found that from 25 to 75 percent of the original soil had been removed from another 16 percent of the land. These figures have additional significance when it is realized that 95 percent of the land has slopes of 5 percent or less.

Strip cropping, here as elsewhere, is a practical method of erosion control. To conform, however, with the conditions imposed by an intensive vegetable-cropping plan, various adaptations are necessary. Different methods are now on trial. The method most commonly used involves the laying of contour lines with parallel cultivated strips 50 to 100 feet wide, depending on the slope. Contour lines are laid out with a maximum deviation of 0.5 percent. Below this cultivated strip another contour line is run but allowing for at least a 20-foot width at the narrowest point between the lower contour line and the last row of cultivated strip above. This leaves an irregular or compensating area between each cultivated strip and the next contour. Generally this area is sown to grain or permanent hay. By reversing the area in cultivation and laying the rows parallel to the lower contour, advantage is taken of the organic matter developed through the grass residues. Point rows in the cultivated strip are eliminated, although in some fields sharply curved rows may result.

The use of broad-base terraces has proved to be a practical and effective ethod of erosion control on vegetable farms (figs. 33 and 34).

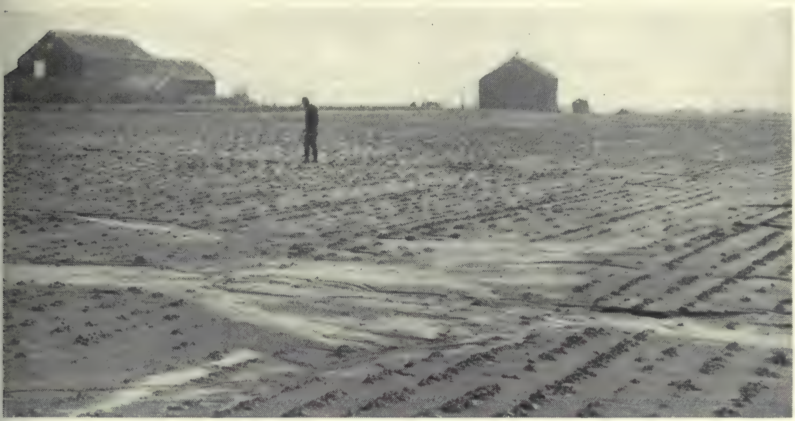


FIGURE 33.—This field, on the Coastal Plain of southern New Jersey, slopes but 3 percent yet heavy rains caused severe sheet wash and damage to the crop of spinach in 1936.

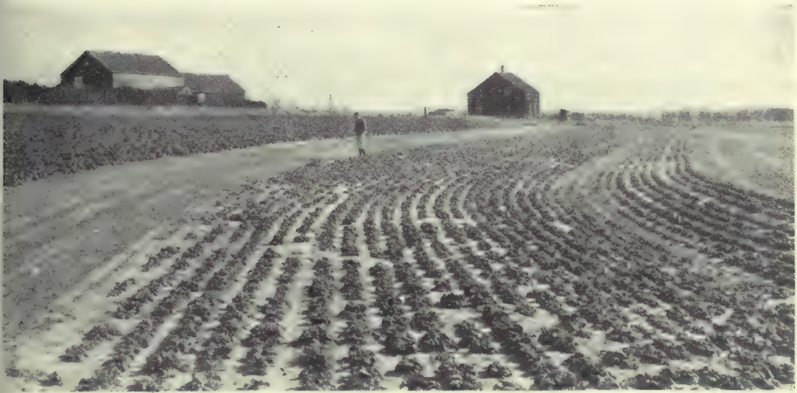


FIGURE 34.—This is the same field as shown in figure 33. Terraces and contour cultivation have reduced soil losses and crop damage.

In the Orchard

Years ago, most of the orchards, both apple and peach orchards, were clean-ltivated. Absence of any vegetation was indicative of superior farming. his clean cultivation, along with the depletion of organic matter in the soil d the fact that most orchards are on sloping land, accounts for much of the osion in orchards. Moreover, numerous trips through the orchards with eavy spray machinery, frequently up and down the slope, left depressions that pidly formed into gullies.

In more recent years the clean cultivation of apples has been discouraged. Although it is now an accepted practice to cultivate peaches in both directions during the growing season, cover crops remain on the land the remainder of the year. Cooperators with the Soil Conservation Service generally cultivate across the slope, and only when necessary will they cultivate up and down the slope. If cultivation both ways is necessary, the first cultivation is up and down the slope, and the second and last is across the slope so that the ridges left by the cultivator or disk will aid in the control of erosion. Wheat, rye, and a mixture of vetch and crimson clover are the winter cover crops that are generally used. Of the three, the mixture of vetch and crimson clover is preferred both for the cultural advantages and increased control of erosion. Its advantage for erosion control lies in the fact that it can be left longer in the spring. Under norma conditions this cover is disked in between April 15 and May 15, depending upon the adequacy of the soil moisture to supply both the trees and the cover. A new winter cover is again sown between August 15 and September 1. The other covers, wheat and rye, are usually disked in earlier than the vetch and crimson clover, and their seeding can be delayed until later in the fall.

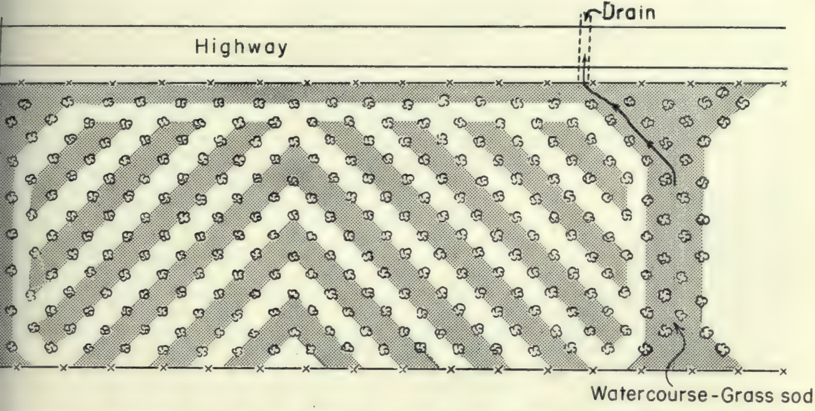
In general, the practice of using clean tillage with seasonal cover crops applies to apple orchards much the same as to peach orchards. There has been a distinct trend, however, toward the use of a permanent cover crop in the apple orchards At the present time alfalfa is the most favored crop. Soil conservationists believe that alfalfa alone is not the most satisfactory cover. In orchards under agreement, a mixture of alfalfa or sweetclover with grasses is used where erosion conditions are hazardous. These crops are mowed at the time when it appears that they are beginning to deprive the trees of needed moisture.

A method which might be considered a compromise between clean tillage and a permanent cover is now being tried in the project area, and early results are promising. Under this plan the alternate middles are placed under a leguminous and grass cover. Plantings of leguminous and grass covers are made across the major slope, and to adapt the practice for erosion control these alternate strips may be run on the diagonal. Even a herringbone pattern may be chosen if the slope of the land makes that practice most feasible (fig. 35). This system, it wil be noted, practically places half of the orchard in strips.

When it is impossible to secure an adequate growth of a cover crop or to use contour methods for erosion control, mulching offers the best substitute. No method used in the project area has given better results. Though too early to draw definite conclusions, it now appears that mulching of the alternate middles will give effective control. Silt carried by water over mulched areas, it has been observed, is usually deposited before it has gone 10 feet. For this reason it is believed that mulching of half the area will be sufficient for erosion control.

For mulching purposes such materials as cornstalks, straw, salt hay, and even weeds may be used. A minimum of 5 tons per acre is considered necessary for e initial application, and the equivalent of from 1 to 2 tons per acre must be plied annually thereafter to maintain an adequate depth of mulch.

Cost of the mulching material and the fire hazard during dry weather have evented its wider use. The fire hazard is minimized when the mulch is used ly on the alternate middles, as described above. The fire hazard, however, is gligible after the mulch has become packed by orchard traffic and made moist rains. Recurrently, storms and high tides from the Atlantic deposit con- derable quantities of salt hay along the right-of-way of highways at certain ints. Through arrangements made with the New Jersey State Highway ommission, much of this salt hay has been made available for mulching purposes.



GURE 35.—A herringbone pattern of alternate seeded strips with clean tillage has been developed in this New Jersey orchard.

In 1907 M. B. Waite built terraces and planted a peach orchard on the contour his farm in Prince Georges County, Md. About the same time Charles E. yan, of Harford County, Md., planted an apple orchard on the contour. His chard lay on a 40-percent slope. In time, movement of soil toward the trees cultivation shaped bench-like terraces along the contour lines made by the ws of trees. Throughout the Northeast these two mature orchards offer actically the only time-tested examples of the effectiveness of contour planting d terracing that can be found. New plantings now being made by cooperators ith the Soil Conservation Service are on the contour if there is any real slope to e land. Terraces are constructed on most of these proposed orchard sites fore the actual planting is done.

In the construction of terraces for a proposed peacn orchard, engineers for the il Conservation Service keep in mind that the conservation and uniform dis- ibution of moisture will be beneficial in addition to the soil that is saved. herever possible, and for the same reason, a terrace for each row of trees is vored (fig. 36). In order to conserve as much moisture as possible and because the construction and maintenance of outlets are expensive, especially on th steeper slopes, level terraces are used whenever soil conditions permit and where the chances of success are favorable.

The horizontal distance between terraces and tree rows in proposed peach orchards usually varies between 20 and 25 feet. These terraces are small when compared with the standard broad-base terrace used under field conditions. A present terraces that have a cross section of about 5 square feet are favored. B moving all of the earth from the upper side, on slopes of up to 10 percent, these structures can usually be completed by making two and one-half or three round with an 8-foot or a 10-foot blade terracer.

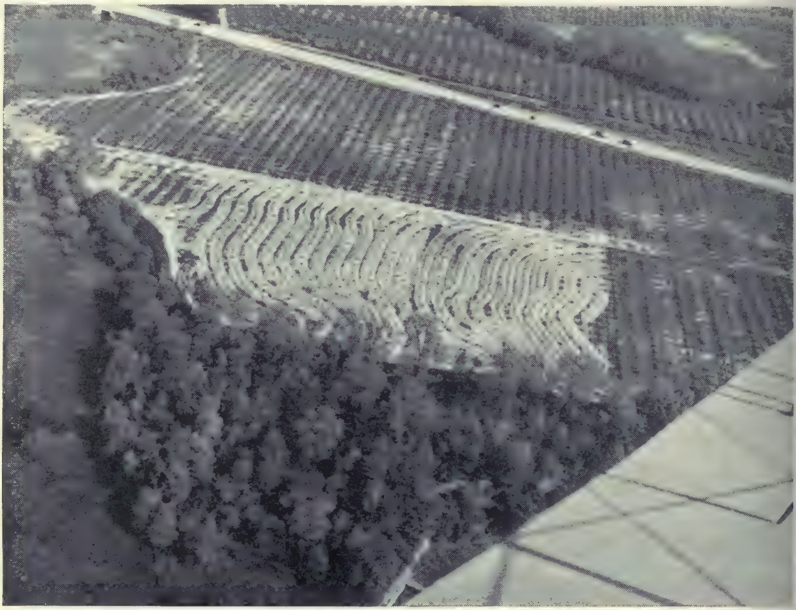


Figure 36.—Air view of a peach orchard planted on small orchard terraces. Note the spur rows

In the case of apple orchards a horizontal spacing of 40 feet, with a correspondingly larger channel cross section, is generally recommended. The reason fo this recommendation is that the usual distance between tree rows in a mature apple orchard is 40 feet. Sometimes the apple orchards are interplanted with peach trees, which usually die about the time thinning operations become necessary in an apple orchard; or, apple trees are planted in rows 20 to 25 feet apart and alternate rows are removed after the trees reach such size that it is impossible to work between them. In such cases terraces should be constructed for every row of trees in order to distribute the moisture supply equally. From an erosion control standpoint this is not important where orchards are kept in permanent sod.

Terrace spacings vary to conform to the slope of the land. When this space
uals the width of two tree middles a spur or short row of trees can be provided.
some cases several spur rows of varying length can be planted between ter-
ces. If the spur rows cannot be cultivated conveniently, they can be mulched.
While terraces or diversion ditches may be constructed in established orchards,
is procedure almost always necessitates the removal of an excessive number of
ees, and the maintenance of the terraces is more difficult than where trees are
anted on the terrace ridges. The number of trees to remove in a peach orchard
paced 20 to 25 feet apart) is greater than the number in mature apple orchards,
here the rows are 40 feet apart. The number of trees to remove for terracing
usually between 8 and 15 percent. In most places it is impossible to cultivate
rallel to the terraces if they are constructed after the trees have become estab-
shed on the square-planting system. In apple orchards it is usually possible to
tablish a permanent sod, but even so, there is a possibility of damaging the
rrace ridge in spraying operations and the removal of fruit.

In old orchards where active gullies are present and terracing is impossible,
fective results are frequently obtained by the use of temporary check dams.
hese structures are located in tree rows and do not interfere with cultivation
ross the slope. Wire dams are usually favored, although other materials may
used. Care must be taken that a well-laid brush or rock apron is provided, so
at serious erosion will not be caused by the overfalling action of water. Areas
otected by these check dams are vegetated and maintained as sodded water-
ays.

Maine—The Aroostook Area

Aroostook County, Maine, roughly equals the land area in the State of
assachusetts. It is Maine's most northern county and the East's last frontier.
hough by 1900 the principal waves of land occupation had stopped at the
ores of the Pacific, settlement was still underway in the woods of northern
aine. Today in Aroostook it is not uncommon to find men in their fifties who
de tractors over soil they themselves have stripped of its primeval forest cover.
nd although timber cutting has dwindled in late years, potatoes are still claim-
g the land against the trees. Potato acreage expanded from 85,000 acres in
20 to 133,500 in 1934.

The railroad from Bangor did not strike through until 1895. The expanding
d extensive potato industry dates from then. The crop rose from 2 million
shels in 1890 to 6 million bushels in 1900 (fig. 37). In 1910 it was 17 million
shels, and in 1920 it was 21 million bushels; by 1930 it was 41 million, and by
35 it was 46 million.

If this area is approached from the south by auto, one must drive 130 miles
orth from Bangor (at least 60 of them through the woods) to reach the potato
untry. There, spread before one is a gently rolling countryside, fringed on

the west by the forest wall and on the east by the Canadian border. The bulk of the potato crop is grown in a narrow strip from one to three townships wide, little more than a speck on the map in fact; yet from this area rolls forth about one-ninth of the potato crop of the United States.

The climate and soil of this northland country provide a natural habitat for the potato. Applied science, as reflected in the control of diseases, the improvement of varieties, the increased application of commercial fertilizers, has pushed average yields far above those of any other State in the Union. But it is not science, solely, that has pushed up yields. As in all new parts of the country, worn-down land has been traded for new; and the virgin soil taken has yielded robustly for a while. With yields rising, scientists as well as farmers have been inclined to overlook visual evidences of soil erosion. Muddy water in the rivers, piles of silt on the highways, and small growing gullies through potato fields, have caused no general concern. Unless the gullies became so deep that farm machinery could not be driven across them they were considered little more than an annoyance.

FIGURE 37.—The Aroostook potato acreage rose from 85,000 acres in 1920 to 133,500 acres in 1934.

While many growers have made commendable progress in combining legumes, small grain, and grass crops along with the intertilled crop of potatoes, the proportion of these on the whole, and through the years, has been small.

Snow covers the land, as a rule, from November until late in March, and it is protected from erosion at least 6 months of the year. Yet potatoes provide scant summer cover; and since most of the crop is planted in rows up and down the long slopes, soil and water losses are heavy.

Though this land is not old in terms of the years it has been in cultivation, intense cropping has brought soil problems more quickly than in most areas.

ɔtatoes are heavy feeders upon plant nutrients, and Aroostook farmers early ırned that yields could be maintained or increased by using commercial ·tilizers. The old standard application, in vogue for years, was about 2,000 2,500 pounds of a 4-8-7 or a 4-8-10 fertilizer to the acre. More recently plications have tended to increase, but yields on many of the earlier-tilled ils fail to respond as they once did.

Growing potatoes on the same soil year after year will, of necessity, reduce d gradually exhaust the supply of organic matter, thus making the soil less sorptive to water. One of the visible effects is an increase in soil erosion.

Many of the more alert growers have recognized that the organic-matter pply must be maintained or increased. Red and alsike clover, when plowed der as a green-manure crop, seemed to meet this need, for clover failures ere relatively uncommon prior to 1920. In 1924 Verne C. Beverly, the unty agricultural agent, noted that red clover failures were rather general roughout the county, and the loss was attributed to an infestation of black ny cutworms. The following year clover failures were again common, but ere were few cutworms. Hence cutworms were not wholly to blame. That ar Beverly made a large number of tests to determine the acidity of the soil. e found many soils too acid to permit the growth of clovers.

A. K. Gardner, crops specialist for the extension service at the University of aine, states that probably less than 200 tons of lime were used in Aroostook unty prior to 1925. But it was from these scattered farms where lime was plied that the county agent discovered many good clover stands. At the time, e belief was prevalent that lime could not safely be used on potato land because ne would promote the development of scab. It might be possible, Beverly asoned, that a small amount of lime—enough to permit clover growth—could applied without inducing scab. Eighteen farmers applied about 200 tons of ne in 1926. The results were favorable, and by 1934 over 8,000 tons of lime ere applied on Aroostook farms. In the 5-year period 1927–31 successful clover tches were recorded on 89.7 percent of the demonstration plots, as compared ith 25.3 percent on check plots where no lime was used. Meanwhile, in 1928, e Maine Agricultural Experiment Station started tests to determine how much ne should be applied. Their results show, that as a general rule, 1,000 pounds high-analysis and finely ground limestone or hydrated lime will be sufficient r a good catch of clover, without inducing scab, even when the soil is strongly id. This Station introduced crimson clover in 1929, and by 1934 over 8,000 res were grown in the county.

Nature, through her normal processes, provided Aroostook County with a ick mantle of soil material. While several different soils occur in Aroostook e one which predominates is known as the Caribou loam. It is characterized its reddish brown color. While the subsoil is relative-thick in comparison ith the topsoil the entire profile to bedrock will not average over 4 to 5 feet in depth. In many cases the ledge is very close to the surface and outcrops a hummocks or bare spots. Even so, if a potato grower had the opportunity o compounding an ideal soil for potatoes he could scarcely improve on this soil o Aroostook County.

This surface soil is sour or acid enough to prevent the growth of scab organisms Aroostook potatoes grow bright and clean. The soil becomes less acid as on goes deeper and at 20 inches conditions are favorable for scab. At 24 inche conditions are still more favorable for scab because the soil contains larger quan tities of calcareous or limey materials than the soil in the upper layer.

If sheet erosion is permitted to reduce the depth of the surface soil, the tim will come (indeed it has arrived for a few fields) when the plowshares will brea through into the subsoil that is more favorable for scab development. Today o farms that have been in cultivation for less than 20 or 30 years it is not uncom mon to find whole fields retired permanently to hay or pasture because the lan became so thin and ledgy that it was no longer profitable to cultivate. If thi ledge contains enough free lime "scabby" land will develop.

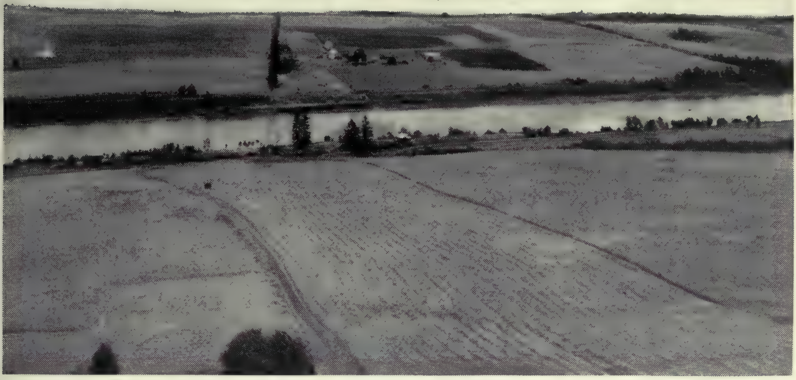
The 30,000-acre project in Aroostook County, designated as project No. 1, i the first demonstration in Maine to be conducted by the Soil Conservation Serv ice. It is in fact the first in New England. Roughly triangular in shape, th area is bounded on two sides by the Aroostook River, a part of which leads fro Presque Isle to Caribou and then in a hairpin turn leads toward Fort Fairfield The lower border is determined by the highway leading from Fort Fairfiel through Maple Grove back to Presque Isle. Within this area are approximatel 250 farms of from 50 to 600 acres each.

When the project was established in 1936 soil surveyors made a study of nin farms within the area to determine the extent of erosion. Of the 1,831 cultivate acres in these nine farms, the surveyors found that 1,247 acres were damaged b sheet erosion labeled "moderate to severe"; 359 acres were declared "severel eroded;" and on only 222 acres could the erosion be called "slight."

During the same year Joseph Chucka, head of the soils department at th Maine College of Agriculture, supervised a similar survey, though more ex tensive, covering 40 farms scattered throughout the potato-growing sections o the State. These 40 farms contained 3,443 acres. Only 47 acres revealed littl or no erosion. It was found that 881 acres had lost less than 25 percent of th surface soil. From 2,290 acres, or about 66 percent of the total acreage, 25 to 7 percent of the surface soil had been lost. Seventy-five percent or more of th surface soil had been removed from 67 acres. From the remaining 158 acres, a of the surface soil and a large amount of subsoil were gone, and only a shallov cover over the bedrock was left.

If it is assumed that the original surface soil on these 3,443 acres was 12 inche deep, 3 inches or less of the topsoil has been removed from 881 acres; 3 to inches of soil from 2,290 acres; 6 to 9 inches of soil from 67 acres, and all the top soil and a large amount of subsoil from the remaining 158 acres.

Logically the first step in developing an erosion-control program was to reshape ields and boundary lines to harmonize with the slope of the land so that contour ultivation could be employed (fig. 38). One of the difficulties encountered in oing this had its inception when the land was first occupied. Many of the irst settlers obtained much of their holdings through squatters' rights. "Broad houlders and personality," it is said, frequently determined how much frontage ach settler would have along the Aroostook River. And it was generally ssumed that each squatter was entitled to land a "long ways back" and up from he river front. Though later divisions and additions have reshaped the original attern of boundary lines, one still finds numerous farms that are long and arrow. One farm, on which an erosion-control program is now in effect, is 43 ods wide and extends a mile back and up on a slope of more than 10 percent n an average.



IGURE 38.—Many fields in Aroostook County have been cultivated up and down the long slopes, thus permitting water to rush to the rivers unimpeded.

The erosion-control measures which have been given the most emphasis in the roostook area are contour cultivation, strip cropping, and a rotation of crops hat will increase the supply of organic matter in the soil and at the same time ive a better balance in the crop acreage.

The strip-cropping plan is based on a 3-, 4-, or 5-year rotation, and it is so rranged that the strips in potatoes are separated by the strips in hay or grain. hen possible, the 3-year rotation of potatoes, grain, and hay is used to hasten he accumulation of organic matter. In some instances, however, when steep and is being converted to permanent sod it is necessary to use on the remaining ropland a 4-year rotation consisting of potatoes, potatoes, grain, and hay to btain enough acreage in potatoes to provide an adequate cash income. In the event that little hay is required, practically the entire crop of hay may be plowed under for green manure.

Width of the strips in general is determined by soil type, slope, and the extent of erosion in a particular field. Aroostook soils normally are more absorptive of rainfall than are the soils in many other areas; and since potatoes are ridged in hills 8 to 12 inches in depth, it is possible to use wider strips than those in use elsewhere. Few strips are less than 150 feet wide; a few are as much as 350.

Normally snow does not leave the land early enough to permit spring plowing prior to the planting season. For this reason fall plowing is customary. Some farmers who have sod strips to plow will leave a narrow buffer strip until spring. During the spring thaw this buffer strip spreads and checks the flow of water. It takes little time in the spring to plow this buffer area prior to the preparation of the entire strip for planting.

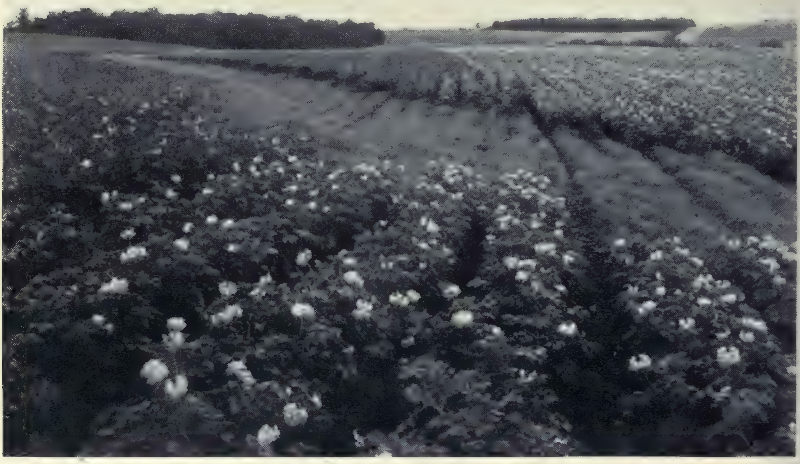


FIGURE 39.—This natural waterway was seeded in the spring of 1937 after potatoes had been planted.

Natural depressions or drainageways in all strip-cropped or cultivated fields are retired to permanent sod, and tillage implements are raised when crossing them (fig. 39).

Terraces, the first in New England, are under trial on a few farms. When these terraces were being designed, engineers kept in mind the machinery which farmers are now using. Structures in use so far have been placed on comparatively even sloping land. At present, at least, it is not expected that terraces will be advocated for rough land or steep slopes.

On fields where considerable erosion is taking place and terraces are not applitable, diversion terraces (fig. 16) have been used. For both diversion terraces and terraces, adequate outlets must be provided for the concentrated water. In Aroostook County it is usually possible to find a well-sodded pasture or a forested area where this water may be safely discharged. If not, provisions are always made to care for this water by constructing outlets.

Numerous check dams have been constructed in gullies to prevent further cutting. Most of these dams are of the temporary type and are designed to check the flow of water until vegetation can be established. Material available locally such as rock, wire, and logs have been used most frequently.

The following tabulation reveals some of the major changes which have been effected on 56 farms in the area, where a cooperative program has been in effect. These changes in land use were effected as of December 31, 1937.

	Acres
Total area of 56 farms	8, 122
Total cropland	4, 725
Approved rotations	4, 725
Contour strip cropping	2, 804
Field strips	1, 500
Land retired permanently to hay	338

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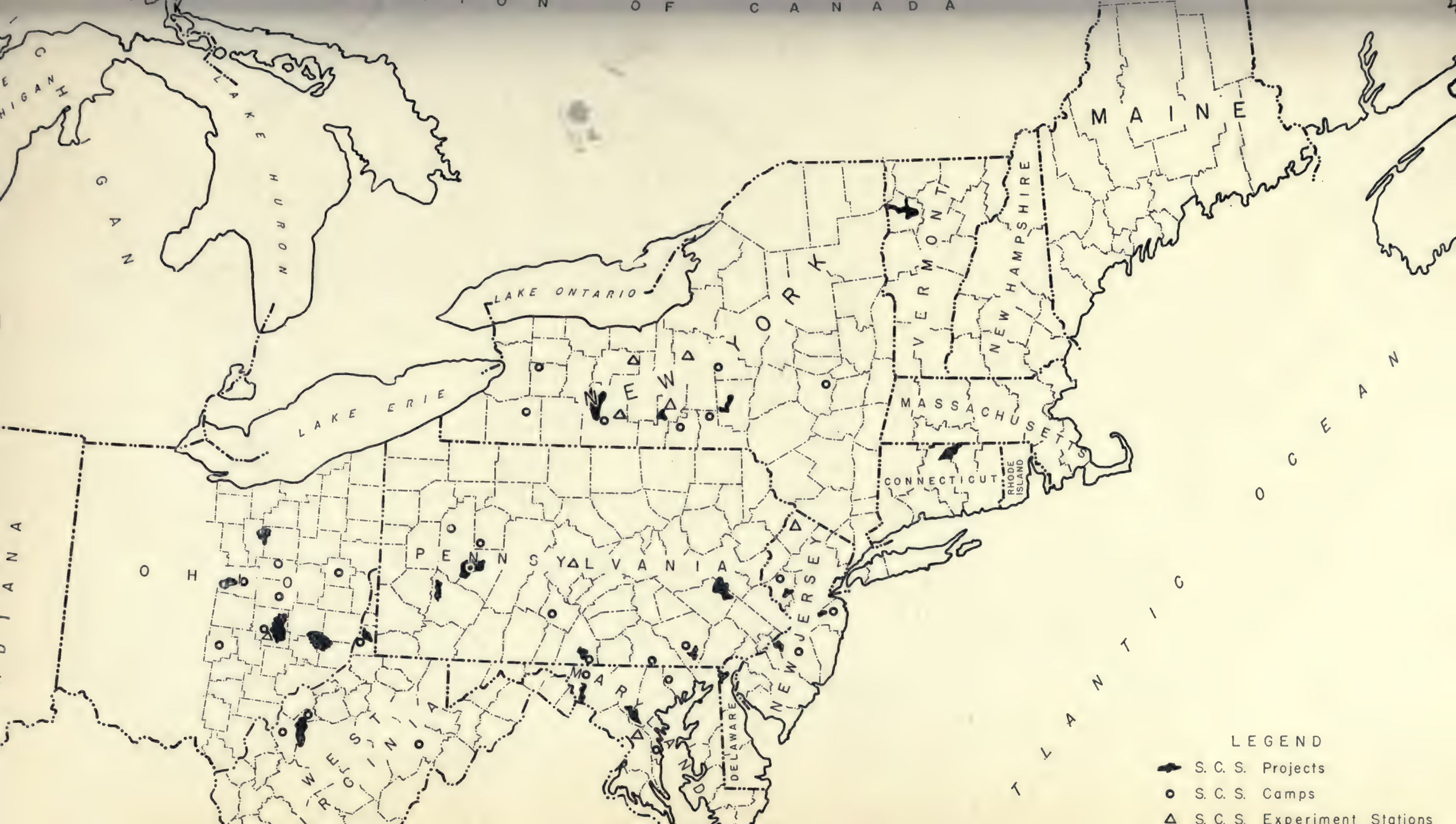
OF CANADA
MICHIGAN
LAKE HURON
LAKE ONTARIO
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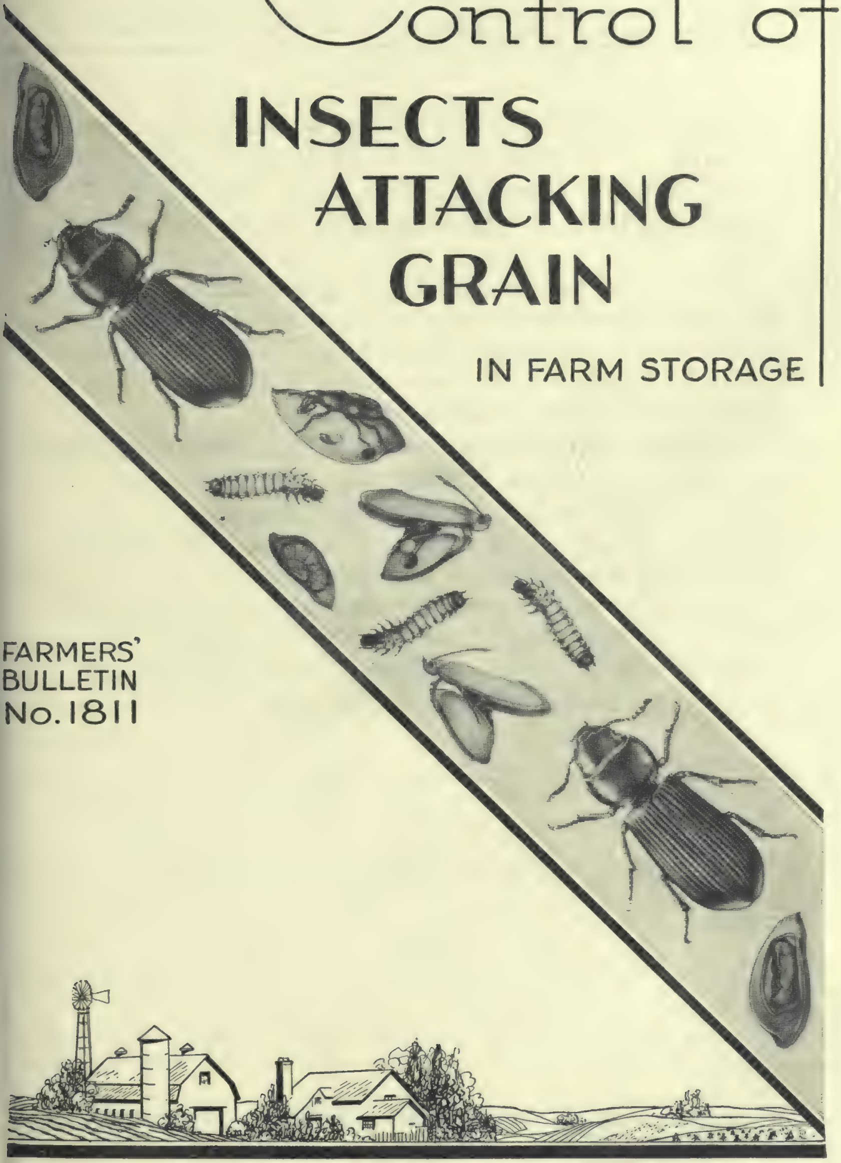
UNITED STATES DEPARTMENT OF AGRICULTURE

Control of INSECTS ATTACKING GRAIN IN FARM STORAGE



FARMERS'
BULLETIN
No. 1811

IN MANY PARTS of the United States grain cannot safely be stored unless it is properly protected from insects. This protection is so difficult in the South that farm storage of grain is not recommended there.

The insects most injurious to grain in storage are the Angoumois grain moth, the rice weevil, the cadelle, and the several "bran bugs." These are described briefly, and conditions that favor their multiplication are pointed out.

The most common causes of insect damage to grain are failure to clean out the bins thoroughly before they are filled with the new grain and storing near the bins quantities of feed that have been purchased from mills where insects are abundant.

Grain that has become infested with any species of insect should be fumigated as soon as possible. This bulletin tells about the different kinds of fumigants, their cost, and how they should be used.

Washington, D. C. **Issued October 1938**

CONTROL OF INSECTS ATTACKING GRAIN IN FARM STORAGE

By R. T. Cotton, *senior entomologist, Division of Cereal and Forage Insect Investigations, Bureau of Entomology and Plant Quarantine*

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NEED FOR SPECIAL PRECAUTION IN PROTECTING FARM-STORED GRAIN

IN MANY GRAIN-GROWING REGIONS of the United States grain cannot be safely stored on the farm unless special precautions are taken to protect it from the ravages of insects. In the South, and in portions of the soft red winter wheat regions of the Central and Eastern States, infestation begins in the field as the ripening wheat and corn are nearing maturity. This initial infestation develops and spreads in the grain after storage until it reaches serious proportions. Unless prompt measures are taken to control it, serious losses result.

In all regions it is customary to store grain year after year in the same bins. If the bins are made of wood, cracks and crevices become filled with grain dust and harbor many insects. Insects such as the cadelle burrow into woodwork to rest and pupate, and later emerge in enormous numbers. Many bins are constructed with an inner lining of tongue-and-groove boards that may not reach to the top, and any space back of them forms a pocket that frequently becomes filled with grain that is difficult to reach and serves as a perpetual breeding place for grain-loving insects. In the rush of harvest it is difficult to find time to clean out these bins, before new grain is stored in them; hence insects in accumulations of old grain and in cracks, crevices, and burrows quickly contaminate the entire new crop.

A common practice on the farm is to store bran, shorts, and other milled feeds in the granary. Occasionally cleanings from flour mills, sweepings, or damaged or infested flour and meal may be purchased as cheap sources of feed. These products may harbor such insects as the confused flour beetle, the red flour beetle, the saw-toothed grain beetle, the flat grain beetle, the rust-red grain beetle, and numerous other pests of grain and milled products which sooner or later migrate to the bins of new grain. Such a situation is shown in the accompanying illustration (fig. 1) of a typical barn granary.

THE MORE IMPORTANT INSECTS THAT ATTACK STORED GRAIN

A brief account of the more important insect pests of stored grain and their relation to infestations of grain stored on the farm is given below.

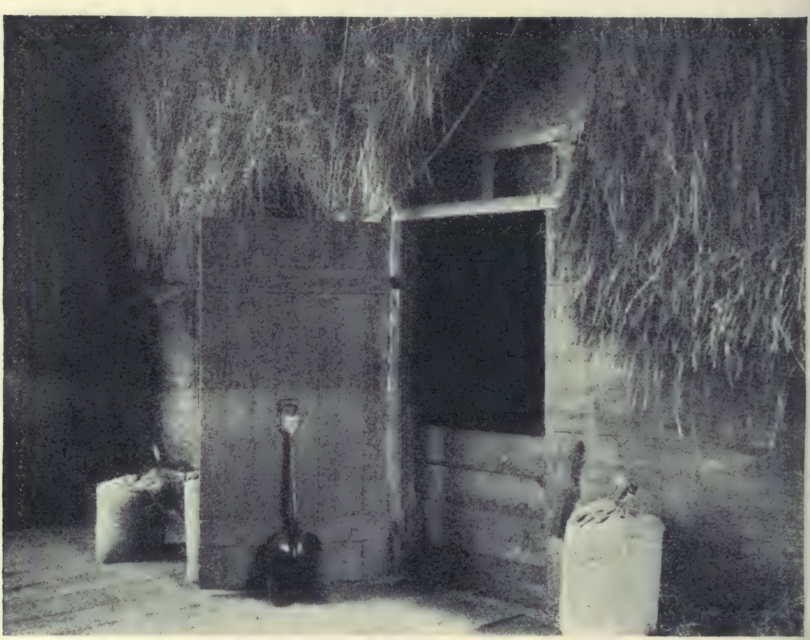
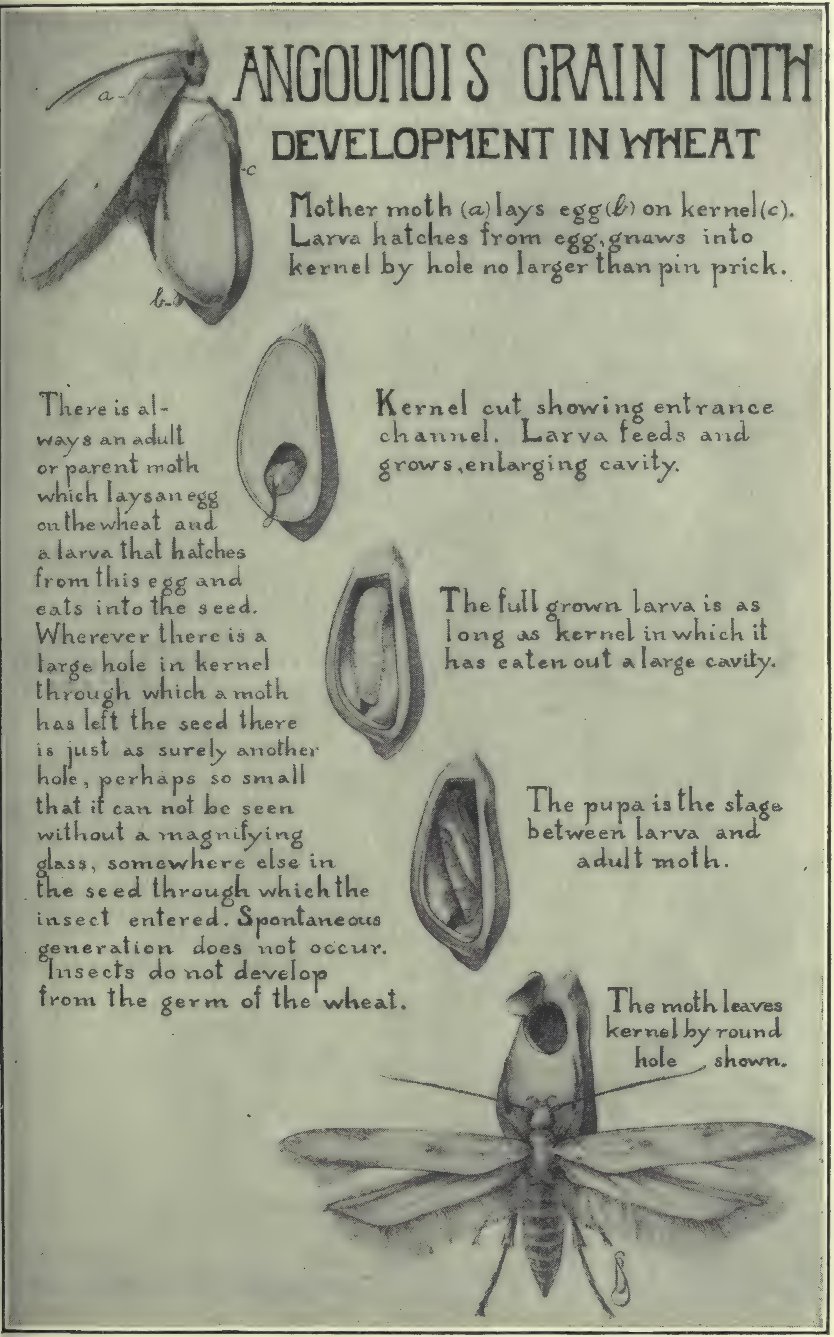


FIGURE 1.—A typical barn granary. Note bags of feed.

THE ANGOUMOIS GRAIN MOTH

The Angoumois grain moth (*Sitotroga cerealella* (Oliv.)) is the moth most commonly found in infested grain. In the South and portions of the soft red winter wheat region of the Eastern and Central States it flies to the fields of ripening corn and wheat as these crops are nearing maturity, and lays eggs upon the wheat heads or corn kernels. These initial infestations take place in the grain when it is in, or passing, the milk stage and usually involve a very small percentage of the kernels. A study of field infestations of wheat in Maryland in 1924 showed an average infestation of 0.26 percent of the kernels at harvest time.

From harvest time until wheat is threshed and stored, however, infestation by the Angoumois grain moth can increase with great rapidity, and in some years infestation of wheat may reach 90 percent by the end of September if threshing is delayed as long as that.



ANGOUMOIS GRAIN MOTH

DEVELOPMENT IN WHEAT

Mother moth (a) lays egg (b) on kernel (c). Larva hatches from egg, gnaws into kernel by hole no larger than pin prick.

There is always an adult or parent moth which lays an egg on the wheat and a larva that hatches from this egg and eats into the seed. Wherever there is a large hole in kernel through which a moth has left the seed there is just as surely another hole, perhaps so small that it can not be seen without a magnifying glass, somewhere else in the seed through which the insect entered. Spontaneous generation does not occur. Insects do not develop from the germ of the wheat.

Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.

The full grown larva is as long as kernel in which it has eaten out a large cavity.

The pupa is the stage between larva and adult moth.

The moth leaves kernel by round hole shown.

FIGURE 2.—Life cycle of Angoumois grain moth on wheat.

When the wheat is in the straw, it is easy for the moths to make their way from one wheat head to another, with the result that infestation is unimpeded; but after the grain is threshed and stored it is impossible for the soft-bodied moths to make their way below the surface of the grain, and infestation is restricted to the surface grain.

Between crops the moths breed in grain in barns, granaries, and corncribs and in waste grain in and around strawstacks.

Each female moth lays, on an average, about 40 eggs, although as many as 389 eggs have been recorded from 1 moth. The eggs, which are laid on or near the grain, hatch into minute white larvae, or caterpillars, that bore into the kernels of grain and begin feeding on the contents. When full-grown, each larva eats out a channel to the outside of the seed but leaves a thin layer of the seed coat intact. It then changes to a reddish-brown pupa, and later the adult or moth emerges, pushing aside the thin section of seed coat that covers the exit from the channel. The development from egg to adult may be completed in 5 weeks. Figure 2 shows the successive stages in the development of this insect in a kernel of wheat from the time the egg is laid until the moth appears. Typical injury to the kernels of an ear of corn are shown in figure 3.

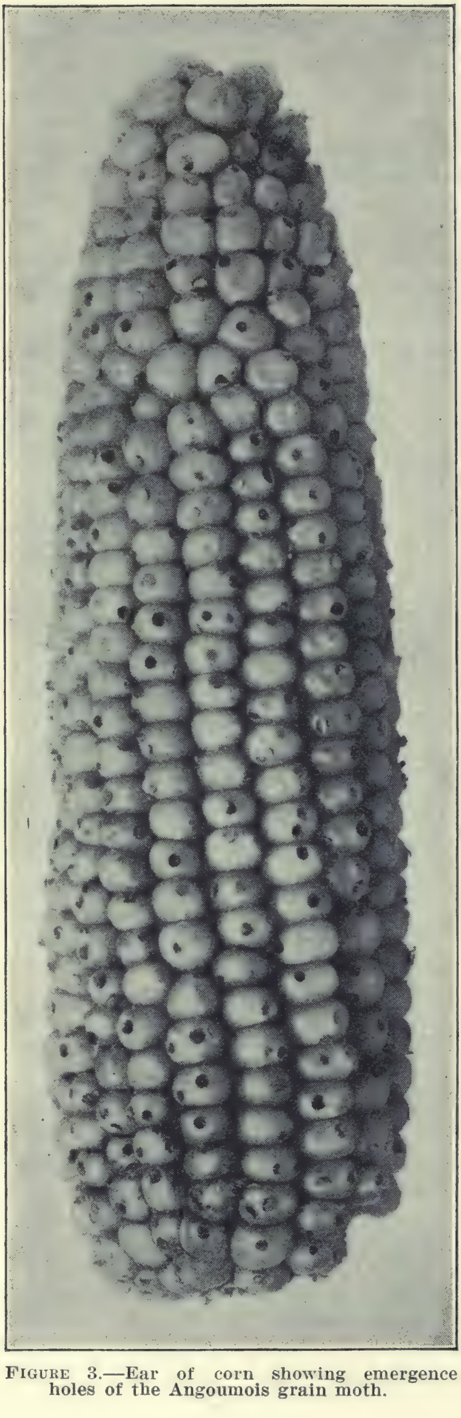


FIGURE 3.—Ear of corn showing emergence holes of the Angoumois grain moth.

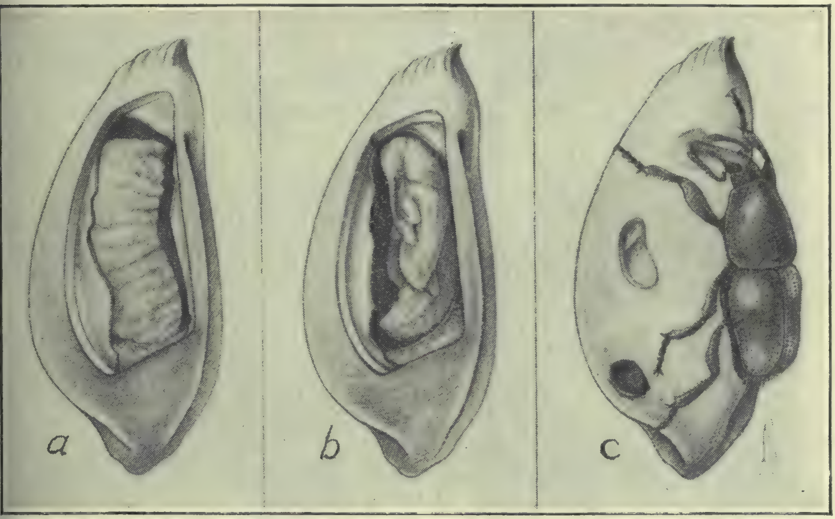
Damage to wheat by the Angoumois grain moth can be largely eliminated by the prompt harvesting and threshing of the crop. Fumigation fter the grain is threshed will then prevent further damage from he initial small infestation that may be present.

In the Northern States, injury by the Angoumois grain moth to orn is not severe except when this crop is stored for more than one eason.

THE RICE WEEVIL

The rice or black weevil (*Sitophilus oryzae* (L.)) is the most detructive insect pest of stored grain. It is a small reddish-brown eetle with head prolonged into a long, slender snout, at the end of vhich are a pair of stout mandibles or jaws. It is further characerized by being marked on the back with four light-reddish or yelowish spots.

The adults fly from granaries or other places containing grain to he fields of corn and wheat in the South and start the infestations hat prove so disastrous after the grain has been harvested. In the nore northern grain-growing regions this weevil is prevalent in ccumulations of old grain in and around granaries, barns, and eleators, and starts infestations in the new grain when it is stored in arm bins or elevators. It is the commonest of the serious pests of ommercial grain shipments.



IGURE 4.—Life stages of the rice or black weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on having the seed and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence.

The adult weevil, the full-grown larva or grub, and the pupa re shown in figure 4. Both adults and larvae feed voraciously on a reat variety of grains.

The adult weevil lives on an average from 4 to 5 months, each emale laying between 300 and 400 eggs during this period. Before aying her eggs, the female bores a small hole in the grain with her nandibles. When this has been made she turns about and lays in t an egg, which she covers with a gelatinous fluid that seals the ole. The small, white fleshy and legless grubs that hatch from the

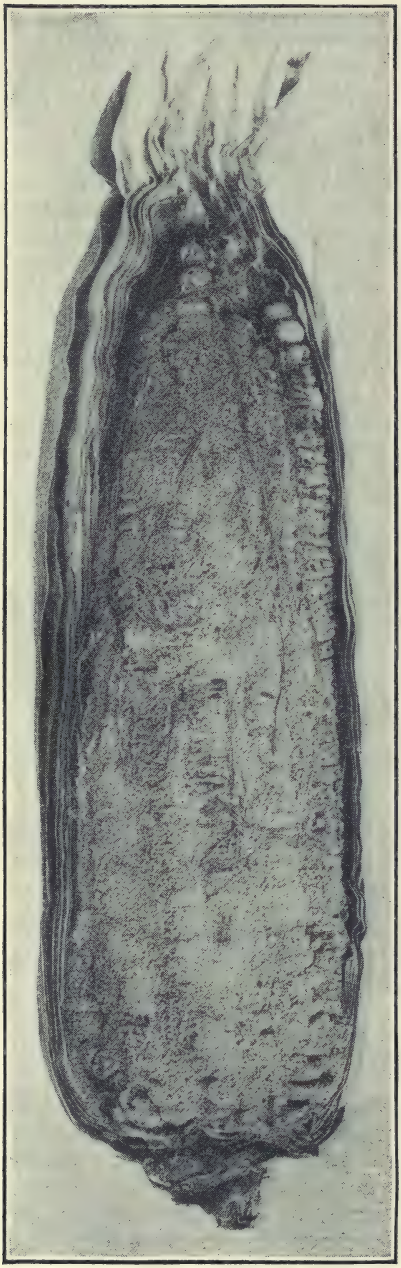


FIGURE 5.—In the South corn is infested by the rice weevil in the field, and unless the corn is fumigated and stored in insect-tight cribs it is soon reduced to the state of the ear shown above.

eggs burrow about inside the kernels and never leave them. When fully grown, these grubs transform to pupae and then to adult weevils, which bore their way out of the grain. During warm summer weather the egg, larval, and pupal stages may be passed in as few as 26 days.

A closely allied species, the granary weevil (*Sitophilus granaria* (L.)), has no wings and cannot infest grain in the field. This insect is usually found in bins and elevators in the Northern States.

The only way to protect grain in the South from damage by the rice weevil (fig. 5) is to fumigate the grain in tight bins immediately after harvest. In the North, infestations by this insect can be largely prevented by storing the grain in bins free from infestation and fumigating it after it is placed in storage.

THE CADELLE

The larvae of the cadelle (*Tenebroides mauritanicus* (L.)) have the unfortunate habit of burrowing in enormous numbers into the woodwork of bins and may remain there for long periods, only to come out when fresh grain is placed in the bin. Many seemingly clean and empty bins may actually harbor thousands of hungry insects, and it is not an uncommon sight to see newly threshed grain literally swarming with worms a few weeks after being placed in wooden bins. Owing to this habit of the larvae of burrowing into woodwork, this insect is one of the commonest pests of grain stored on the farm in all parts of the country. The burrows, which are well illustrated in figure 6, also afford hiding places for many other grain-infesting insects.

The adult cadelle (fig. 7) is an elongate, oblong, and flattened, black beetle about one-third of an inch long. It is one of the longest-lived of the insects that attack stored grain. Many of the adults live for more than a year and some for nearly 2 years. The females lay about 1,000 eggs each, which hatch in from 7 to 10 days into fleshy,

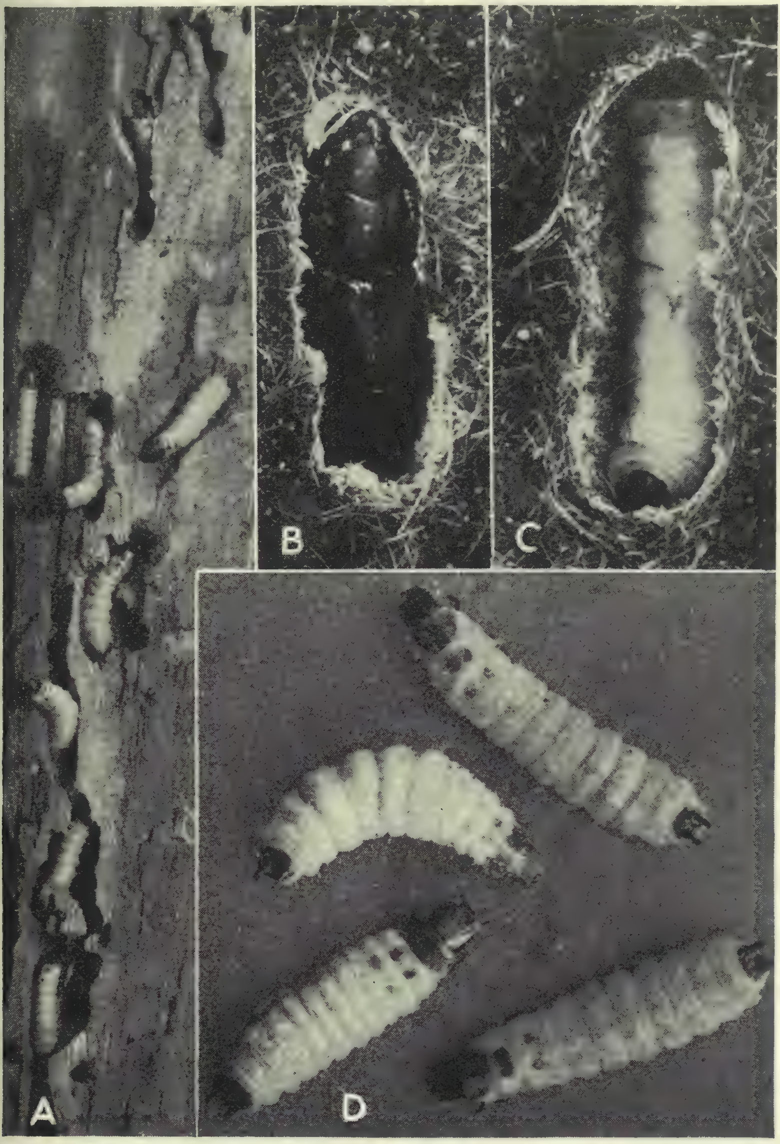


FIGURE 6.—Hibernation of the cadelle: *A,* Sectioned softwood board from granary used for wheat storage, showing numerous larvae of cadelle using board for protection during winter months; *D,* cadelle larvae about to pupate; *C,* cadelle larvae hibernating in pupal chamber; *B,* same as *C,* only several months later, after larva has transformed to adult.

chalky-white larvae with black heads and 2 horny black points at the end of their bodies. When fully grown the larva is about three-fourths of an inch long. The developmental period from egg to adult may be completed in 70 days under favorable conditions but frequently takes much longer.

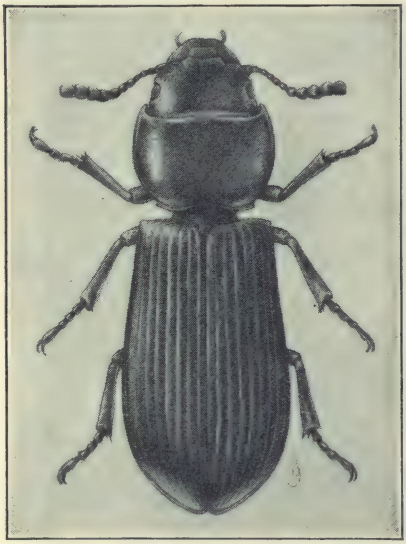


FIGURE 7.—The cadelle, one of the most common pests in in farm-stored grain.

The best insurance against this insect is to clean empty bins thoroughly and fumigate newly stored grain within a few days after it is stored.

"BRAN BUGS"

Several species of beetles that are not primary grain pests but feed on broken grain and grain dust follow up the attack of the true grain beetles and complete the work of destruction. They are referred to by grain inspectors as "bran bugs." These are one-sixteenth to one-seventh inch long and reddish brown in color. The confused flour beetle (*Tribolium confusum* (Jacq.-Duv.) (fig. 8) and the red flour beetle (*T. castaneum* (Hbst.)), which are included in this group, are the worst pests in flour, and their presence in grain constitutes the chief source of infestation in flour mills. The saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)) (fig. 9) and the flat grain beetle (*Laemophloeus minutus* Oliv.) (fig. 10) are other typical examples of bran bugs.

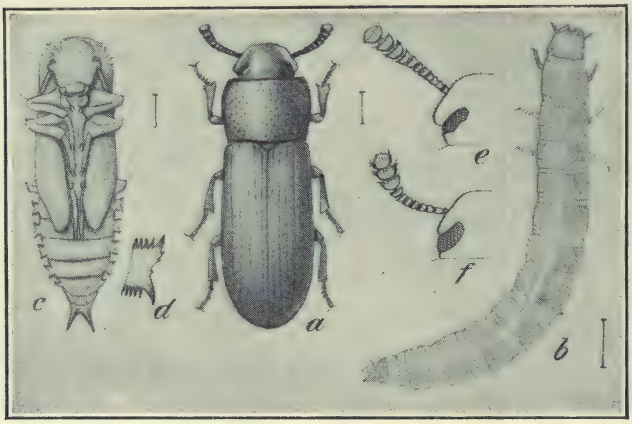
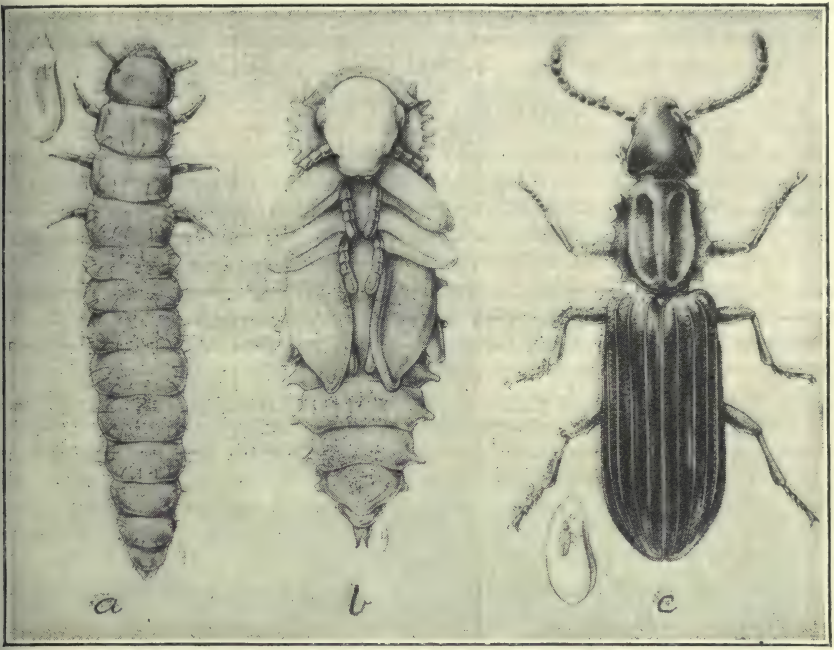


FIGURE 8.—The confused flour beetle, one of the most important of the so-called bran bugs. It is about one-sixth of an inch long. *a*, Beetle; *b*, larva; *c*, pupa; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of the red flour beetle.

The practice of storing millfeeds, chicken feed, and screenings in or near the granary and failing to clean out accumulations of in-



IGURE 9.—The saw-toothed grain beetle, a frequent inhabitant of stored grain: *a*, Well-grown larva; *b*, pupa; *c*, adult beetle.

ested grain from bins is largely responsible for the infestation of rain by bran bugs. Feeds and screenings are usually infested with nsects of this type, and the habit of these insects of migrating when hey become abundant, or when they are dis-urbed, insures the infestation of any nearby rain or cereal product.

Storing grain in bins well removed from all nilled feeds, chicken feed, or other cereal roducts, and cleaning out bins before the stor-ge of grain will do much to prevent infesta-ion by bran bugs.

PREVENTIVE MEASURES

Owing to the fact that the insect hazard to arm-stored grain is not the same in all regions fig. 11), problems pertaining to farm storage f grain in the principal grain-growing regions f the country will be discussed and directions given for treating and handling the grain to revent or lessen losses from insect attack.

In all parts of the country grain stored for considerable length of time is subject to in-ury by insects. To avoid this injury it is ecessary to store the grain in tight bins or uildings in which it can be effectively fumigated. The type of construction necessary for

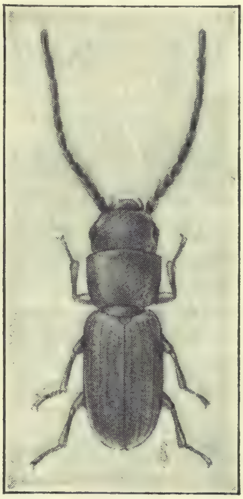


FIGURE 10.—The flat grain beetle, the smallest bran bug found in stored grain, and often more numerous than any other species.

proper fumigation is described in Agricultural Adjustment Administration bulletins, Wheat Storage in the Ever-Normal Granary, and Corn Storage in the Ever-Normal Granary.

GRAIN STORAGE IN REGION 1

Region 1 (fig. 11) comprises for the most part the spring wheat area of the Northern States, the semiarid white wheat area of the Pacific Northwest, and the northern portion of the hard and soft winter wheat areas. In these areas wheat can be stored on the farm with greater freedom from insect damage than in any other section of the country. The chief source of infestation is from insects in accumulations of old grain, in cracks, crevices, and burrows in the woodwork of bins, and from infested millfeed and chicken feed stored on the farm.

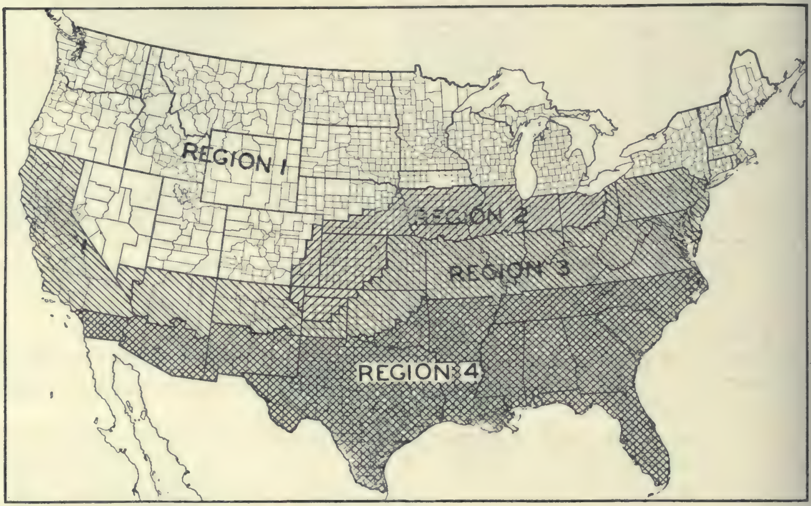


FIGURE 11.—Regional map of the United States, indicating relative hazard to farm-stored grain from insect attack: Region 1, best adapted for safe farm storage; region 2, hazardous for farm storage in some years—frequent inspection and occasional fumigation necessary; region 3, hazardous for farm storage every year—frequent inspection and fumigation necessary; region 4, farm storage unsafe and not recommended—insect control difficult.

Grain-storage structures of all kinds should be thoroughly cleaned, accumulations of old grain removed, and the woodwork sprayed before new grain is stored. Inspection in the fall and subsequent inspections at monthly intervals during the warm weather of the following year are recommended to detect the presence of insect infestations. Grain found infested should be fumigated without delay.

GRAIN STORAGE IN REGION 2

Region 2 (fig. 11) includes the southern portion of the hard winter wheat area of the Great Plains and the northern section of the soft winter wheat area of the Central States. As is the case in region 1, the chief source of infestation is insects in accumulations of old grain in cracks, crevices, and burrows in the woodwork of bins, and infested millfeeds and chicken feed stored on the farm. During seasons of undant rainfall, wheat is high in moisture and particularly susptible to attack, and damage to farm-stored grain in this region ay be extensive.

Grain-storage structures of all kinds should be thoroughly cleaned, cumulations of old grain removed and woodwork sprayed before w grain is stored. Monthly inspections of stored grain should be ade after harvest until the advent of cold weather. Subsequent spections at monthly intervals during the warm weather of the folwing year should also be made to determine the presence of insect festations. Grain found to be infested should be fumigated witht delay.

GRAIN STORAGE IN REGION 3

Region 3 (fig. 11) comprises the central section of the soft red inter wheat area of the Eastern States, the southern portion of the entral States, and the white wheat area of California. The susceptility of wheat to field infestations of the Angoumois grain moth in e Eastern States makes it necessary to thresh the grain as soon ter harvest as the wheat is dry, to insure it against possible severe mage. In the entire region wheat is also highly susceptible to the tack of other insect pests of stored grain; hence it is necessary to migate all wheat as soon as possible after it is placed in storage.

In this region, cleaning out the bins before the storage of new ain is essential. The use of a good contact spray that will peneate cracks and burrows but will not contaminate or impart an odor the new crop of grain is also recommended. Except during the inter, inspection of stored grain should be made monthly throught the year. Corn grown in this region is usually stored in slat cribs at cannot be fumigated. The Angoumois grain moth frequently insts corn so stored, but little serious damage is done unless the corn held over the summer following harvest. If storage of corn for ore than one season is contemplated, the corn should be shelled fore the end of the first year of storage after the corn has become oroughly air dry, stored in tight bins, and fumigated.

GRAIN STORAGE IN REGION 4

Region 4 (fig. 11) includes areas in the South and Southeast in hich farm storage is extremely hazardous except for short periods. this region infestation begins in the field and is frequently extenve before grain can be harvested and placed in storage. The warm, umid climate favors rapid multiplication of stored-grain insects, d the chances of sound grain becoming reinfested from outside urces are greater here than elsewhere.

Thoroughly cleaning the bins prior to storage of the new grain is ghly important, since old accumulations of grain in this region are variably infested. If grain is stored, it should be fumigated imediately and monthly inspection made thereafter to determine the esence of infestations. Additional fumigations should be made henever such infestations are discovered.

FUMIGATION

For treating infested wheat or corn in storage on the farm there nothing cheaper, more effective, or more readily available than rbon disulphide.

Although the fumes of carbon disulphide are inflammable and explosive when mixed with air in certain proportions, this fumigant can be handled with reasonable safety if the proper precautions are taken. It should not be used to treat bins located in barns where the fire hazard cannot be properly controlled and where a fire or explosion will endanger human life or lead to losses of farm animals, farm equipment, buildings, and stored crops. It is well adapted, however, for the treatment of grain storages that are segregated from other farm buildings. The fumes of this gas are quickly absorbed by the grain after application, and the danger from fire or explosion is not prolonged.

If grain bins are located on farms where the fire hazard cannot be controlled, a mixture of carbon disulphide with carbon tetrachloride or a mixture of ethylene dichloride and carbon tetrachloride should be used. These mixtures do not have the fire hazards of carbon disulphide when used as grain fumigants. They are not so toxic as carbon disulphide alone and must be used in larger quantities, and hence are more expensive.

CARBON DISULPHIDE

Carbon disulphide is a colorless, volatile liquid, which boils at 115° F. On exposure to air it evaporates, forming a heavy vapor that is capable of penetrating through deep bins of grain, and is highly toxic to insects.

It is applied by being sprinkled evenly over the surface of the grain in the bin by means of a watering can or similar device, at the rate of from 1 to 3 gallons per 1,000 bushels, depending upon the temperature of the grain and the tightness of the bin. The cooler the wheat, the larger the dosage required. Fumigations at grain temperatures below 60° F. are not highly effective. The use of a tarpaulin to cover the grain after the fumigant is applied will aid in confining the vapor.

The vapor of carbon disulphide is poisonous to human beings if breathed for an extended period. Exposure to light concentrations may induce a feeling of giddiness, which, however, will quickly pass off when one comes out into the fresh air. Small quantities of carbon disulphide can be handled without danger by the ordinary person, although persons having any heart trouble should take little part in its application.

The vapor of carbon disulphide is very inflammable and explosive. Therefore, fire in any form must not be allowed near a bin or building that is being fumigated with this chemical. It must be remembered that lighted lanterns, cigars, pipes, cigarettes, sparks from electric switches, static or frictional electricity, sparks caused by hammering upon metal, or even hot steam pipes may cause an explosion of carbon disulphide vapor.

Carbon disulphide weighs about 10½ pounds per gallon and ranges in cost from about 6 cents a pound in 500-pound lots to 30 cents a pound in 1-pound lots.

MIXTURES OF CARBON DISULPHIDE WITH OTHER CHEMICALS

Mixtures of carbon disulphide with other chemicals, such as carbon tetrachloride and sulphur dioxide, to reduce the fire hazard are now available commercially at a price of about $2 per gallon f. o. b.

factory. These mixtures consist of approximately 20 percent of bon disulphide and 80 percent of carbon tetrachloride, to which y be added a small quantity of sulphur dioxide or other chemicals. hen properly made, such mixtures appear to be relatively free from hazard. It is not advisable for the layman to attempt the manu- ture of such mixture, since the safety from fire hazard of the nigant is dependent upon its proper preparation. Only such mix- es as are sanctioned by fire-insurance underwriters should be d. The toxicity of carbon tetrachloride to man is about equivalent that of carbon disulphide.

hese mixtures should be used at the rate of from 3 to 5 gallons per 00 bushels according to the temperature of the grain and the tight- s of the bin, if the results are to be comparable with those obtain- e from carbon disulphide alone. The fumigant is applied in the ne manner as carbon disulphide, by sprinkling it evenly over the face of the grain.

ETHYLENE DICHLORIDE-CARBON TETRACHLORIDE MIXTURE

Ethylene dichloride, a recently discovered fumigant, is effective tight bins at temperatures above 70° F. Since the vapors of ethyl- dichloride are slightly inflammable, it is customary to use this nigant in combination with carbon tetrachloride. A mixture of 3 rts by volume of ethylene dichloride with 1 part of carbon tetra- oride is free from fire hazard under ordinary conditions. It can used as a substitute for carbon disulphide under circumstances ere carbon disulphide cannot safely be used.

Ethylene dichloride is a colorless liquid with an odor similar to t of chloroform. It evaporates slowly when exposed to air, form- a vapor that is heavier than air and that will penetrate grain in a nner similar to carbon disulphide vapor. It has no adverse effect on the germination of seeds and is not dangerous to handle. It has anesthetic action when breathed in concentrated form, but unless fumes are breathed for a protracted period no harmful results d be feared.

n admixture with carbon tetrachloride it should be used at the e of from 3 to 5 gallons per 1,000 bushels of grain and can be plied in the same manner as carbon disulphide.

t can be purchased in 55-gallon drums at a cost of 6.44 cents per und delivered.

FUMIGATION OF GRAIN IN SMALL ELEVATORS

n some wheat-growing regions grain is stored on the farm in small vators that are equipped with machinery for handling grain and nsferring it from one bin to another. The bins in such elevators usually of the open-top crib type and may have a capacity of out 5,000 bushels. Grain stored in such elevators can be treated a different manner from grain in farm storage that cannot be ndled. Fumigants can be applied to the grain while it is being ved from one bin to another, so that the fumigant is well dis- buted, and there is a choice of chemicals. One of the two most isfactory grain fumigants under these conditions is a mixture of bon disulphide, carbon tetrachloride, and sulphur dioxide.

Bins in elevators of this type are usually filled over a period o several days. Fumigation will therefore ordinarily be delayed unti a bin is filled.

CARBON DISULPHIDE MIXTURE FOR USE IN FARM ELEVATORS

If the carbon disulphide-carbon tetrachloride-sulphur dioxid mixture is used, it can be applied entirely to the surface of the grai of the filled bin in the same manner recommended for the treatmen of smaller farm bins. A dosage of 2 gallons of the mixture per 1,00 bushels of grain is recommended. If the grain is warm, the surfac method of application will give satisfactory results. If the grai is cool or cold, better distribution of the fumigant can be obtained b spraying, pouring, or dripping it into the grain stream as the grai is transferred from one bin to another.

SPRAYS

Sprays used in treating empty bins should not be of a type likely t contaminate or impart an odor to the grain that will be placed i storage, otherwise the grain will be classed as "sample grade" on account of the odor. Any odorless, tasteless, water-white petroleu similar to that contained in commercial fly sprays for use in dwellings, to which has been added a small quantity of pyrethrum extract is satisfactory. Since oil sprays are inflammable, care should be exercised in applying such a spray to prevent fires.

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FARMERS' BULLETIN No. 1812

NATIVE AND ADAPTED GRASSES FOR CONSERVATION OF OIL AND MOISTURE IN THE GREAT PLAINS AND WESTERN STATES

UNITED STATES DEPARTMENT OF AGRICULTURE
1862 1889

THE INFORMATION given in this bulletin should enable farmers in the Great Plains and Western States to select from the more common species of grasses some one or more suited to their needs. Common harvesting equipment and farm machinery can be adapted to the proper handling of native grasses. This brings the cost of such work within the means of most farmers.

The distribution maps and data presented in this bulletin are based on publications of the Department of Agriculture, particularly those of the Bureau of Plant Industry and the Forest Service, as well as on information gained in the field activities of the Soil Conservation Service. Federal and State agencies have cooperated at the several grass nurseries of the Soil Conservation Service and have assisted with this work.

Washington, D. C. Issued February, 1939

NATIVE AND ADAPTED GRASSES 'OR CONSERVATION OF SOIL AND MOISTURE I THE GREAT PLAINS AND WESTERN STATES

M. M. HOOVER, *senior agronomist, Section of Conservation Nurseries, Division of Conservation Operations, Soil Conservation Service*

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INTRODUCTION

N MOST FARMS in the Great Plains and Western States there are fields that should be revegetated, and the native grasses of the ion, together with a few adapted introduced grasses, have proved st suitable for the purpose.

)nly when the growth habits and the erosion-resistant properties a grass are known can the best use be made of that grass, whether be planted on range or pasture, on eroded abandoned areas of the m, or in contour strips in cultivated fields.

Eroded and depleted lands are not all of one type; nor can they all restored by the same treatment. In gullies, for instance, sodming grasses, such as vine-mesquite and Kentucky bluegrass, will ch and hold the soil particles carried in the run-off. In drainageys and terrace channels that carry excessive amounts of flood ter during flash storms, grasses with vigorous, heavy root systems needed that will resist the cutting effect of the water. The heavy tstocks and densely massed roots of western wheatgrass make it excellent plant for such use. These roots and the leafy top growth, nt down blade upon blade under the pressure of the water, make a ıt through which water cannot cut its way to destroy the soil.

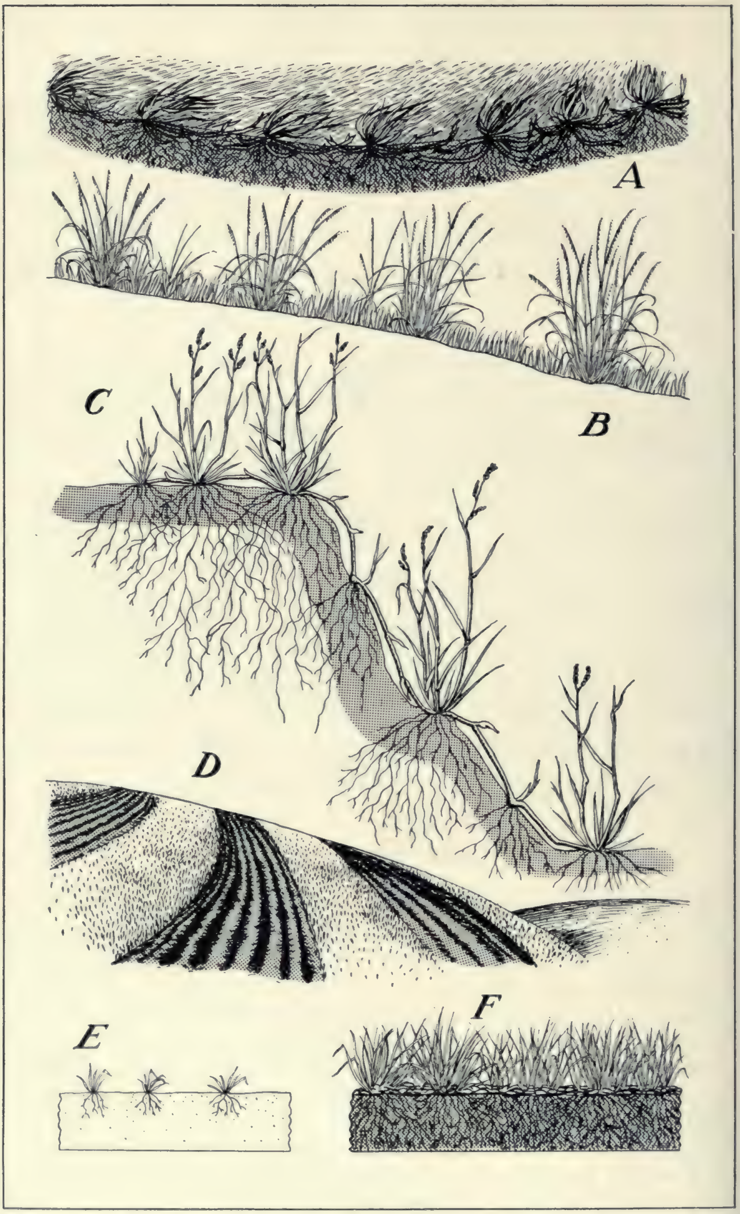


FIGURE 1.—*A*, The vigorous growth of rootstocks of western wheatgrass forms dense sod highly resistant to the cutting of the water in drainageways, and the to growth forms a mat over which the water travels easily; *B*, side-oats gram produces volunteer seedlings that protect sloping lands with a permanent sod *C*, vine-mesquite soon spreads a dense turf down the sides of a gully or strea bank by sending down new roots from the nodes on its stolons or runners; little bluestem is used widely in regular rotations in contour farming becaus of its high forage value and fibrous root system; *E*, infertile soil; *F*, accumula tions of vegetative litter above ground and the decay of the fibrous grass root in the soil improve fertility.

A grass, such as vine-mesquite or Bermuda grass, that has widely eeping stolons by which it can establish new plants may spread very oidly and provide an effective vegetative cover in a pasture or on an oded area; yet this same grass may be undesirable for planting in ips on cultivated fields, for it would interfere with cultivation by reading or because of survival of the runners. Many of our so-lled weedy grasses possess characteristics of high economic value if ey can be properly controlled when grown in association with other ints. It is the costliness of proper control methods that limits the der use of certain of these grasses.

The deep, extensive root systems of the grasses that can be used on ltivated fields add organic matter to the soil and improve the soil ucture because of the thorough penetration of the fine hairlike roots at tend to bind the soil particles. The decay of the plant roots rmits greater penetration of moisture and air, which adds to the neral fertility and tilth of the soil. The top growth affords protec-n against the wind or the washing of the soil by rains. Plant idue remaining through the winter retains snow as it falls, thus rving as an effective agent in the conservation of snow moisture.

The grasses that are planted for pasture should give to the parti-lar soil and slope on which they grow the protective cover needed. the steeper slopes the sod-forming grasses are required. Yet it ist not be forgotten that to best serve the purpose of soil conserva-n a plant should also be useful as forage or pasture.

Grasses, it is seen, have specialized uses in erosion control; they o have certain growth characteristics that determine what use can made of them in conservation plantings (fig. 1). A plant that will ow on a sandy soil may not thrive on a heavy soil. A grass that ovides adequate ground cover on gentle slopes may not protect the eeper lands; and one that thrives on south slopes may not survive on pes that face the north. One condition may require a plant erant to shade; and another, a grass that can grow with little oisture. A grass excellent in controlling erosion on a stream bank, ere moisture is plentiful, may fail on arid lands.

In considering the particular use to which a grass known to be cellent in erosion control can be put, it is necessary first to know ere this grass will grow. If a grass that protects and enriches the l grows on many different types of soils and under a wide range of matic conditions it will rank high among the grasses used in con-rvation plantings. A small map indicating the major and minor eas of distribution has been prepared for each of the grasses discussed this bulletin. These maps, each showing the natural distribution a given grass, will serve as a guide in the choice of species that may used successfully in artificial revegetation.

Since artificial revegetation requires planting, the seeding habits of asses must be studied. Some grasses shatter their seed soon after ripens, some are not reliable seed producers, and some grow only in attered stands or in locations inaccessible to harvesting machinery. her native stands produce seed of good quality that can be readily rvested.

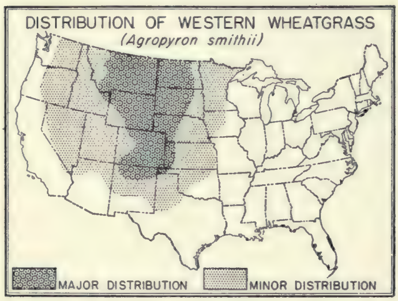
The seeding habits of the grasses and procedures for producing ed under cultivation are discussed in the following descriptions of e different species, as are also satisfactory methods of collecting ed and establishing seedlings.

Information about special equipment and machinery used in th collection and cleaning of native grass seed in quantity is given in separate section.

WHEATGRASS

Four of the wheatgrasses, all adapted to cold climates, find thei greatest usefulness in the northern Great Plains, the intermountai region, and the higher elevations of the Rocky Mountain States. Th fact that these grasses bind the soil, make good forage and groun cover, and are adapted to a wide range of soil and climatic condition places them in the front rank of grasses useful in soil conservation.

WESTERN WHEATGRASS



Western wheatgrass (*Agropyron smithii*), a native perennial, i distributed generally throughout the United States, except in th more humid Southeastern State but is more at home in the norther Great Plains. Pure stands of thi grass are not uncommon, especiall on the heavy gumbo soils of ol lake beds. It is one of the nativ grasses that are used for both pa ture and forage. Western wheat grass has several outstanding cha acteristics that make it exceedingl valuable for use in erosion contro Its rapid growth and strongly creep ing rootstocks (fig. 3) quickly pr duce both a ground cover and a heavy sod. By reason of its tal grainlike growth (fig. 2), its seed can be harvested and cleaned easil and cheaply by the use of ordinary small-grain equipment. Furthe the seed is relatively large and can therefore be sown easily and plante deep. Deep planting assures better germination and establishme where there is little moisture. The tenacious, soil-binding habit this grass makes it especially suitable for reseeding abandoned far lands. This is borne out by the fact that on abandoned farms tha were not clean-cropped too long, good stands of western wheatgras have developed from rootstocks carried over from the time when th land was first plowed.

Western wheatgrass is especially useful for sodding terrace outle and channels as well as for seeding or sodding stream and reservoi banks as a protection against wave action. After the plants becom established the long rootstocks and heavy root system effectivel bind the soil by forming a dense sod and heavy vegetative cover. I gullies and terrace outlets, where the plants receive excess run-o water, the leafy top growth retains the soil particles carried in th run-off and so serves as an excellent de-silter.

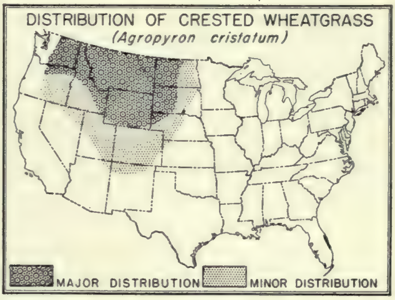
The production of viable seed from native stands is closely ass ciated with favorable moisture and temperature during the earl part of the growing season. As these conditions obtain throughou

of the northern range of the species, this area is the leading
e of seed. But since the wide distribution of native stands
ically insures the possibility of a good seed crop each season
me place within its range it is not necessary to produce seed under
vation. The Soil Conservation Service has collected from native
ls several hundred thousand pounds of seed for use on demon-
ion project areas. These activities have so stimulated interest
is species that seed companies in the Great Plains are now listing
le seed that has been largely collected by farmers from their own

antings in the grass nurseries of selected strains from several
es show wide differences in growth characteristics, including
ness, aggressiveness, and amount of vegetative growth and seed.
mation obtained from field plantings shows that a seeding rate
to 10 pounds an acre is satisfactory if plantings are made in
suitable for cultivation, and a rate of 20 to 25 pounds if seed
illed or broadcast.

CRESTED WHEATGRASS

ested wheatgrass (*Agropyron cristatum;* fig. 4, *A*) was intro-
d from northern regions of the Union of Soviet Socialist Re-
ics. This perennial bunch grass has proved to be particularly well-
ted to the soils and climate
e northern Great Plains and
intermountain region of the
fic Northwest. It is a very
pasture and forage grass, is
tant to extreme drought and
has a deep, extensive root
m, and reseeds readily. It is,
fore, especially suitable for re-
ng in the dry, wind-erosion
s.

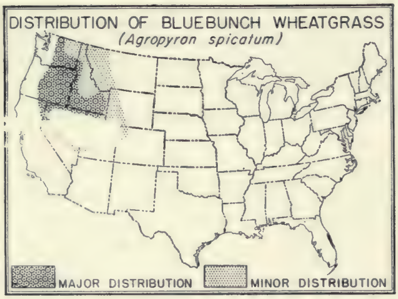


perior strains of crested wheat-
s (fig. 4, *B*) developed by the
t-breeding stations in this country and Canada have been as-
led in the grass nurseries of the Soil Conservation Service for
er observation. Some of these are especially promising for
on control. This grass has been found to be adapted to both
cultivation and closely drilled or broadcast seeding at a rate of
3 pounds per acre in single rows, 4 to 5 pounds in double rows,
10 to 12 pounds in closely drilled or broadcast plantings.

general, spring seeding has been found preferable to fall seeding.
fall planting, however, is becoming rather common in the
hern Great Plains, particularly on trashy, weedy land where the
bed cannot be prepared before the time of seeding. Planting at
season is particularly advantageous in areas where wind erosion
rs, as it makes it unnecessary to lay the ground bare to the action
e wind. Also it aids in the retention of snow and the protection
e plants during the period of their early establishment.

BLUEBUNCH WHEATGRASS

Bluebunch wheatgrass (*Agropyron spicatum*), a native bunch gr is widely distributed and extends from Alaska to California and i New Mexico and Montana. reaches its maximum growth in soils and climate of the Pac Northwest and the intermount region. Figure 5 shows selecti of bluebunch wheatgrass at Pullman, Wash., nursery and an dividual plant.



At one time bluebunch whe grass was very plentiful, but original stands have been dama by overstocking and early spr grazing. Since this grass is very atable and reproduces only from seed, deferred grazing, which mits the old plants to produce their seed crop before livestock tram them into the soil, is recommended as a means of insuring the ma tenance of this grass.

BEARDLESS BLUEBUNCH WHEATGRASS

Beardless bluebunch wheatgrass (*Agropyron inerme*) has the sa distribution as bluebunch wheatgrass (*A. spicatum*) but differs fr it in that it has no awns. Both forms were once common through the intermountain region, and since they can be easily establis from seed they should be used extensively in the revegetation of t region. Improved strains under observation at the Pullman, Wa nursery that are superior in vegetative vigor and seed production being increased for quantity distribution and use.

BUFFALO GRASS

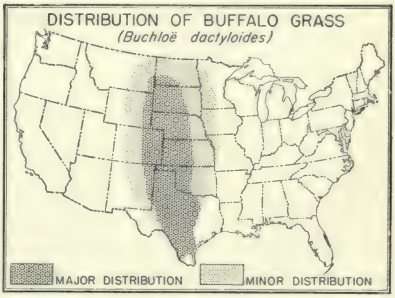
Buffalo grass (*Buchloë dactyloides*), a native sod grass, is the m characteristic plant of the short-grass associations of the semia Great Plains (fig. 6, *A*, *B*). Although frequently found in mixtu with blue and hairy grama, it is the predominating grass of t region.

Buffalo grass makes a close, even turf, produces a large amount nutritious forage, and forms a most effective erosion-resistant s In the southern Great Plains it ranks first among the native gras for wind-erosion control, possessing all the characteristics desired this purpose except that of producing heavy seed crops. Being v drought-resistant, it does well throughout the region except on v sandy soils. It spreads rapidly by means of stolons and withsta heavy grazing. Buffalo grass can be used to line terrace chan and outlets, to strip sod gullies, and to protect earth fills aro ponds and reservoirs.

Buffalo grass has been successfully transplanted by using s Sod pieces 4 inches square and spaced at 4-foot intervals ordina give complete cover within two seasons. In resodding large area practical method of transplanting consists of the use of sheet-i chutes in which pieces of sod are dropped in front of a wagon wh (fig. 6, *C*). The pressure from the wheel pushes the pieces of firmly into the previously prepared seedbed. Vegetative plantin

ugh very effective in establishing a stand, are costly on account
:he large amount of hand labor required.

Extensive use of buffalo grass for erosion control has not been
de, largely because of lack of sufficient seed. Not only does the
nt set comparatively light seed crops, but its peculiar seeding
bit has made the collection of seed very tedious and costly. Seed
borne in short-stalked burs that shatter readily, and once these
s have fallen to the ground they become entangled in the vegetative
ss in such manner as to make their separation and collection very
icult. However, recognition of the value of this grass for conser-
ion use has led to extra effort to obtain the seed. Special hand
thods have proved satisfactory and have been supplemented by
cial equipment that facilitates the collection of seed in quantity.
n making hand collections heavy street brooms and ordinary
-bottomed shovels and dust-
is have been used in sweeping up
seed. The shattered seed burs
concentrated in low areas in
es as the result of heavy rains.
ese depressions are sought out
ing dry weather and the seed
ept up in convenient piles and
n recleaned with a clipper mill.
other small-scale method of col-
ing the seed is to use converted
n mowers with pan attachments
which bristle brushes have been
stituted for the conventional rotating blades. Two pounds of burs
man-hour were collected in this way.



Several special types of motorized equipment to facilitate the col-
ion of buffalo grass seed in quantity have been developed and
ted by the Soil Conservation Service. The most successful of
se machines was designed on the principle of a commercial vacuum
aner. The suction developed from a rotating fan is used to pick
the seed burs from the mass of vegetation. Best success was had
h a small portable machine of this same design having a small
ible nozzle that permitted collection of seed from the concentrated
umulations previously described. Weather conditions play a part
the successful use of this equipment. Heavy rains either carry
ay large amounts of seed or bury it in the soil in such a manner
t its removal by suction is sometimes difficult.

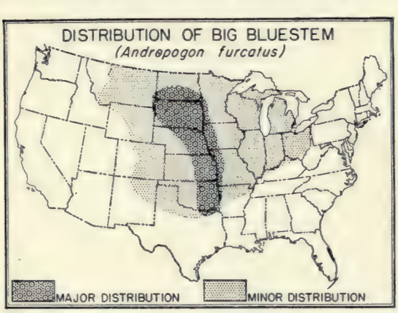
t has been found that buffalo grass seed will remain in good
dition a long time after shattering, and germination studies
icate that old seed germinates much more readily than newly
lected seed. Germination as high as 60 percent is not uncommon.
tting tests indicate an approximate average of one and one-half
ds per bur. Trial plantings at the North Platte, Nebr., nursery
the Soil Conservation Service indicate that the ordinary corn
nter can be used successfully in seeding this grass. Spot planting
buffalo grass burs with small grain, which serves as a row marker
il the grass has become established, permits early cultivation of
grass seedlings.

BLUESTEM [1]

The bluestems comprise a very large group of grasses that is particularly well represented throughout the warmer regions of the world. The species that are of greatest usefulness in soil conservation practices grow in the central Great Plains.

BIG BLUESTEM

Big bluestem (*Andropogon furcatus*) is generally distributed throughout the eastern part of Oklahoma, Kansas, Nebraska, and South Dakota, but in the western part of these States, where climatic conditions are more severe, it is found only in scattered stands on the most favorable sites. The old saying that "big bluestem land is good cornland" is indeed true, for much of the fine agricultural land of the Corn Belt was at one time covered with dense stands of this and associated tall prairie grasses. The plants are usually tall, leafy, and of a bunch habit of growth (fig. 7). They produce excellent pasture and hay. They also furnish effective protection against erosion, owing to the retention of the top growth and the deep penetration of the extensive root system.



During favorable seasons very satisfactory seed crops may be expected from native stands, but nursery plantings have produced higher yields of better quality seeds, especially plantings in which the mother plants were permitted ample space for development.

Information at hand regarding the proper rate, date, and method of seeding indicates that success in establishing stands of this grass depends largely upon the preparation of the seedbed and the depth of seeding. As a usual practice, the seedbed should be prepared as for ordinary grain crops and the seed planted not more than one-half inch deep. The fact that this is a native grass does not mean that it can be planted with any less care than the tame grasses. Rates of 6 to 8 pounds an acre, if it is seeded in rows suitable for cultivation, and 15 to 20 pounds, if seeded broadcast, have been found to give satisfactory stands.

This grass can be readily harvested by power strippers (p. 40), but recent field trials have indicated that the seed may be collected by using small-grain combine harvesters. Yields of 75 to 100 pounds an acre of field-run material averaging 25 percent pure seed by weight have been obtained in this manner.

Big bluestem will no doubt be one of the first native grasses to be grown generally by farmers for the production of seed because the mand for the seed is increasing and farm machinery and methods n be used in its production.

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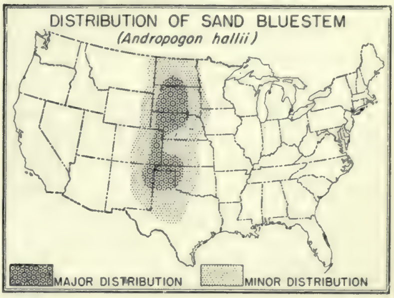
[1] The common name given in Hitchcock's Manual of the Grasses of the United States for the Genus *Andropogon* is beardgrass. The three representatives of this genus mentioned in this bulletin are *Andropogon furcatus*, *A. Hallii*, and *A. scoparius*, for which Hitchcock's manual gives the common names bluejoint turkeyfoot, turkeyfoot, and prairie beard, respectively. In this bulletin, however, the common names "big bluestem," "sand bluestem," and "little bluestem" are used because of their wide acceptance throughout the regions where these grasses are native.

SAND BLUESTEM

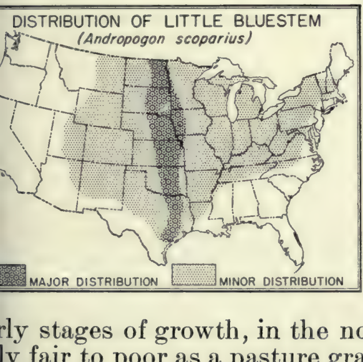
Sand bluestem (*Andropogon hallii*), like big bluestem, is considered cellent for forage and erosion control, but it is distinguishable m big bluestem by its heavy rootstocks and is especially adapted to ry sandy soils. It is therefore one the most desirable of the native isses for use on sandy "blow ls." In the central Plains States ias been used with very good re- ts in stabilizing certain soil types rticularly susceptible to wind ero- n. These plantings were made using rootstocks from the mother nts or by seed. Seeding was st successful when the overripe, threshed hay was placed as a t on the "blow soil" area. This l plant residue serves as a protective cover until the young seedlings come established.



The deep, extensive root system and the tall, stocky growth of this iss make it useful in the establishment of permanent contour strips a protective measure against wind erosion, particularly on the more idy soils of the Great Plains. If these strips were made a part of the gular sequence of crops in a rotation covering several years, they uld serve as a ready source of the seed of sand bluestem. At the sent time seed must be obtained by hand collections from the ttered natural stands.

LITTLE BLUESTEM

Little bluestem (*Andropogon scoparius*) is generally distributed roughout Nebraska, Kansas, Oklahoma, the blackland belt of south-central Texas, northern New Mexico, northern Arizona, Utah, and western Colorado. A perennial native bunch type, it occurs in dense stands where the soil is fertile and moisture plentiful but appears only in scattered clumps when growing on exposed, rocky, or arid sites. Principally because of its leafiness and vigorous root system, it is a very good erosion-control plant (fig. 8). Although it is highly palatable throughout most of its range, particularly during the rly stages of growth, in the northern Great Plains it is considered ly fair to poor as a pasture grass since there it soon becomes rather irse and cattle do not graze it readily.



The seed of this grass can be harvested readily from native stands with power strippers or with small-grain combine harvesters. If collection is made with a stripper, the seed material should be threshed with an ordinary small-grain separator and cleaned with a clipper fanning mill. If harvested with combine harvester equipment, special care should be used in adjustments of air and screens to clean the seed without unnecessary waste.

Seed collected from native stands usually contains various amounts of associated species such as big bluestem, switchgrass, Indian grass, dropseed, and grama. Such seed mixtures are considered desirable for the reseeding done by the Soil Conservation Service because they represent the natural association of grasses that are adapted to the region where the work of revegetation is being done.

Excellent yields of high-quality seed have been obtained in the nurseries of the Soil Conservation Service from plantings in 6-inch paired rows spaced 30 inches apart to permit cultivation. If the seed is planted in this manner, a seeding rate of 6 to 8 pounds per acre is sufficient, but if it is drilled or broadcast on a field scale, 20 pounds is necessary.

A number of selections of little bluestem that possess desirable characteristics for use in conserving soil have been isolated by the United States Department of Agriculture and State experiment station plant breeders. Several of these developed by the Kansas Agricultural Experiment Station have outstanding merit because of uniformity in habit of growth and abundance of leafy foliage, and are now being made available for conservation planting.

Selected strains of both little bluestem and big bluestem, as well as of other native grasses, indicate wide differences in vegetative characteristics. Many of these selections show outstanding promise of superior qualities for use in conservation planting.

GRAMA

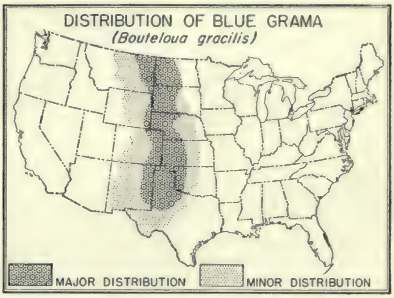
Five of the grama grasses are used extensively for revegetation of range lands. Characteristically, they are a part of the short-grass flora of the Great Plains and are a valuable constituent of the cover on the range land of that area.

BLUE GRAMA

Blue grama (*Bouteloua gracilis*) occurs generally throughout the dry portions of the Great Plains, and in undisturbed soil it is commonly found associated with buffalo grass. In general, it is sod-forming in habit, which makes it especially desirable for use in erosion control. Its growth characteristics, however, vary considerably in different sections. For example, in its northern range, plants have a greater tendency to form sod than in its southern range, where they become taller, more vigorous, and assume more of a bunch habit.

Blue grama has a relatively shallow but very dense root system (fig. 10), and, although well adapted to heavy soils, it is by no means restricted to soils of this type. Because of its high palatability and ızing capacity, as well as its wide soil and climatic adaptation, s grass is excellent as range forage and ranks high for use in range l pasture revegetation.

Seed of excellent quality has been produced at the grass nurseries, ere the plantings were made in double 6-inch rows spaced 30 inches art to permit cultivation. Under these conditions seed has been served to show practically complete emergence within 48 hours er planting. Since plants grown from seed stock obtained from ferent localities show distinct differences in habit of growth, obser- tions are being made with a view to finding the best sources of seed revegetation. Figure 9 shows the marked differences in plants wn at Lincoln, Nebr., from seed lected in Oklahoma, Colorado, w Mexico, and Nebraska. The ıthern strains tend to mature er and to be more vigorous in nparison with those obtained m northern sources.



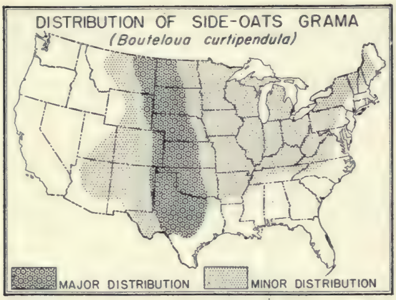
Field seeding practices vary lely, depending upon general en- onmental conditions and the pur- se of the planting. In the wind- sion area of the southern Great ins precautions must be taken to e the newly emerged seedlings protection against wind damage by ding in stubble or other protective crop residue. Good survival, ecially in the central Great Plains, is closely related to the care d in making the seedings. For best results the seedbed needs to carefully prepared, well firmed, and as free as possible of weeds vious to planting. Depth of seeding likewise bears a close relation satisfactory emergence of the seedlings. As the seed is very small, cannot be planted deep. Good stands have resulted from seedings adcast at the rate of 5 to 8 pounds per acre, and from plantings de in rows at a rate proportionately less.

Both spring and fall seedings have been made throughout the ge of this grass, with the result that very late fall planting of blue ma appears most likely to be generally successful in its northern ge and spring seeding throughout the central Great Plains. Favor- le moisture at the time of seeding is particularly desirable.

SIDE-OATS GRAMA

Side-oats grama (*Bouteloua curtipendula*) is the most widely dis- buted of all the gramas and is found generally throughout the ited States east of the Rocky Mountains.

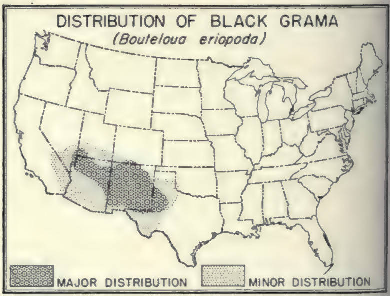
Although a perennial with scaly rootstocks, side-oats grama gener- y assumes a bunch habit of growth. It is found in association with er gramas and because of its leafiness is prized as a forage plant. e stems, however, are not palatable and often remain standing er the leafy foliage has been eaten by livestock. The seed heads are distinctive and can be easily distinguished from those of other gramas because the numerous spikes are arranged bannerlike at one side of the stem (fig. 11). This gives the plant its common name, "side-oats" grama.



For seed production side-oats grama is one of the most promising native grasses that have been grown under cultivation in the nurseries, particularly because its upright growth habit facilitates harvesting. In rows spaced to permit cultivation, yields of 400 pounds per acre of seed have been obtained, and it is notable that the seed produced in this manner was of higher quality than that collected from native stands. Seed from these stands is usually low in viability, seldom giving more than 20-percent germination.

Experience gained from nursery plantings indicates the practicability of bringing this grass into wide use. Its leafy character, comparatively heavy stems, and strongly branching root system, combined with wide soil and climatic adaptations and ease of harvesting and seeding make it one of the most useful of our native grasses for general revegetation. It is considered especially suitable for replanting retired farm lands. Seeding at the rate of 20 pounds an acre if the seed is broadcast or drilled and 8 to 12 pounds if planted in rows has proved satisfactory.

BLACK GRAMA



Black grama (*Bouteloua eriopoda*) is distributed more or less generally through southern New Mexico and Arizona and western Texas. It is one of the good forage grasses of the Southwest. The fact that it spreads by tillers and stolons gives it a high rank as a soil-binding plant and makes it very effective in erosion control.

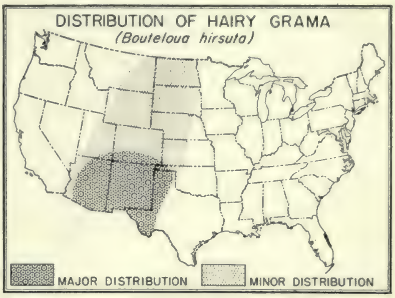
Since it forms pure stands in certain favorable localities, areas that produce satisfactory seed crops can sometimes be found; but this grass does not develop viable seed consistently under natural conditions. In spite of this fact it is believed that the desirable qualities of black grama warrant special effort to bring it into general use in soil conservation. The development of methods of seed production is therefore being undertaken in the grass nurseries of the Soil Conservation Service in the Southwest.

HAIRY GRAMA

Hairy grama (*Bouteloua hirsuta*), a native perennial, is found in ttered stands throughout most of the Central and Rocky Moun- n States. It reaches its maximum usefulness as a range plant in zona and New Mexico, where occurs in mixtures with other sses.

t is adapted to the same general and climatic conditions as blue ma and, like this grass, tends to n sod in the North and to assume unch habit of growth in the th. It is generally distinguished n blue grama by the coarse black rs on the back of the spike.

The natural adaptation of this ss to unfavorable soils and sites uld warrant its use in revegetation where others of the native sses are likely to fail. Because hairy grama is found on rough, ccessible ground and rarely in pure stands, the seed must be ected largely by hand. As this is expensive, the production of d under cultivation may be advisable.

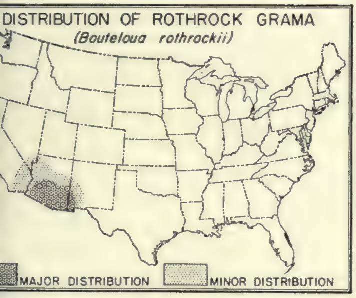


ROTHROCK GRAMA

Rothrock grama (*Bouteloua rothrockii*) occurs in the southern half Arizona and southwestern New Mexico, where it often forms ensive pure stands.

t is an erratic, short-lived perennial, resembling blue grama except for the more numerous flower spikes. Ranchers consider it better than the annual gramas but not as valuable as the blue and hairy gramas, with which it is frequently associated.

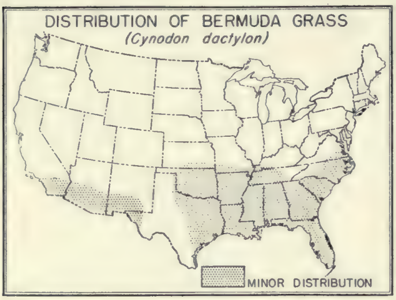
This grass does not withstand overgrazing, but during favorable periods the number of plants increases rapidly because of good seeding habits. With adequate protection it produces excellent cover on relatively sterile soils where but few other species will grow and for t reason especially is desirable for revegetation.



Seed of this grass should be produced under cultivation as the ection of seed from native stands is difficult and expensive.

BERMUDA GRASS

Bermuda grass (*Cynodon dactylon*), commonly called wire grass, a perennial that was introduced from the warmer regions of the Ol World. It is common throughout the Southern States and is foun as far north as Maryland an Kansas, as well as in the warme valleys of the Southwest. It pr duces underground rootstocks an creeping stems that take root readil at the nodes, a combination growth characteristics that mak a very dense sod and gives th grass outstanding value for erosio control although its distribution not wide because of its relativel high water requirement and lack winter hardiness.



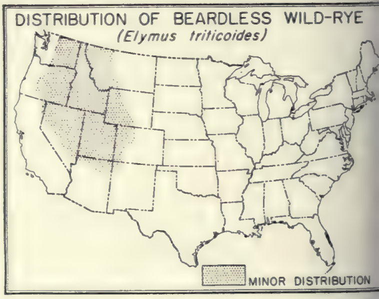
Bermuda grass used in the improvement and development of pastu lands also gives protection to the soil. In the South it is the mo effective grass for use as a lining for terrace outlets and diversio ditches and as a protection for gully banks. After becoming we established, the sod serves not only as a good soil binder but also an excellent de-silting agent. This grass is readily established fro seed, stolons, or rootstocks.

WILD-RYE

Three of the wild-rye grasses are being used extensively in so conservation operations. Medium palatability is characteristic of th group of grasses, but their excellent seed habits, heavy foliage, an relative ease of establishment place them among the most valuable grasses for use in revegetation.

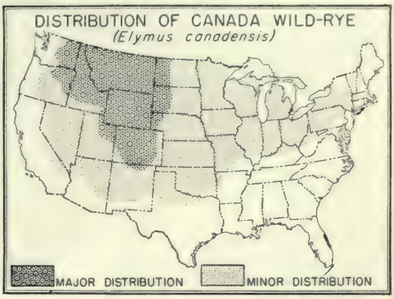
BEARDLESS WILD-RYE

Beardless wild-rye (*Elymus triticoides*) (fig. 12) is a heavy, sod-forming grass resembling western wheatgrass, with which it has frequently been confused. It is well adapted to the alkali and prairie soils and climate of the Pacific Northwest. Its extensive creeping rootstocks and colonizing habit growth, its heavy foliage, and ability to produce good seed make it a excellent grass for erosion control. The plants tend to become coars and woody when mature. Although this reduces their palatability, greatly increases their usefulness as a ground cover.



CANADA WILD-RYE

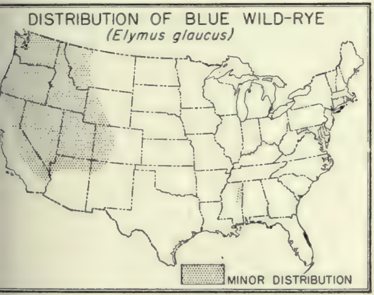
Canada wild-rye (*Elymus canadensis*) (fig. 13) is generally dis- ibuted throughout the cooler portions of the United States and ıds its most suitable soils and climate in the northern Great Plains, the Pacific Northwest, and at higher elevations in the Southwest. is a vigorous, tall-growing peren- al that produces an abundance of liage and seed. As forage the ass is somewhat unpalatable, but is is offset by the very rapid ger- ination and quick vegetative ver furnished by newly planted edlings. Under heavy grazing is is one of the first species to sappear; but, if properly pro- cted, it becomes quickly reestab- shed and supplies excellent protec- ve ground cover.



Since this species does not form pure stands, it is necessary to llect seed by hand if it is to be obtained from natural stands. Seed excellent quality and yield has been obtained from nursery plant- gs, and it appears essential for this species to be grown under ltivation to produce the required seed. Canada wild-rye has a ace in conservation planting because of its ability to establish im- ediate vegetative cover.

BLUE WILD-RYE

Although found generally throughout the Western States, blue ild-rye (*Elymus glaucus*) (fig. 14) is most abundant in the Pacific Northwest, where it is considered valuable both for range forage and erosion control. It is much like Canada wild-rye in habit of growth, except that it has shorter awns and a somewhat finer foliage, and, as the name indicates, is covered with a whitish or bluish bloom.



In native stands this grass rarely grows alone, but is mixed with other grasses or weeds. The fact that it bears seed in abundance, establishes itself readily when given encourage- ent through proper protection, and produces a good ground cover ves it a high value for use in soil and moisture conservation. Ob- rvational plantings at the Pullman, Wash., nursery indicate great ıriation in this as well as the other ryegrasses. One of these selec- ɔns that shows particular promise because of its dense ground ɔver, palatability, and ease of establishment is being increased for ıantity use.

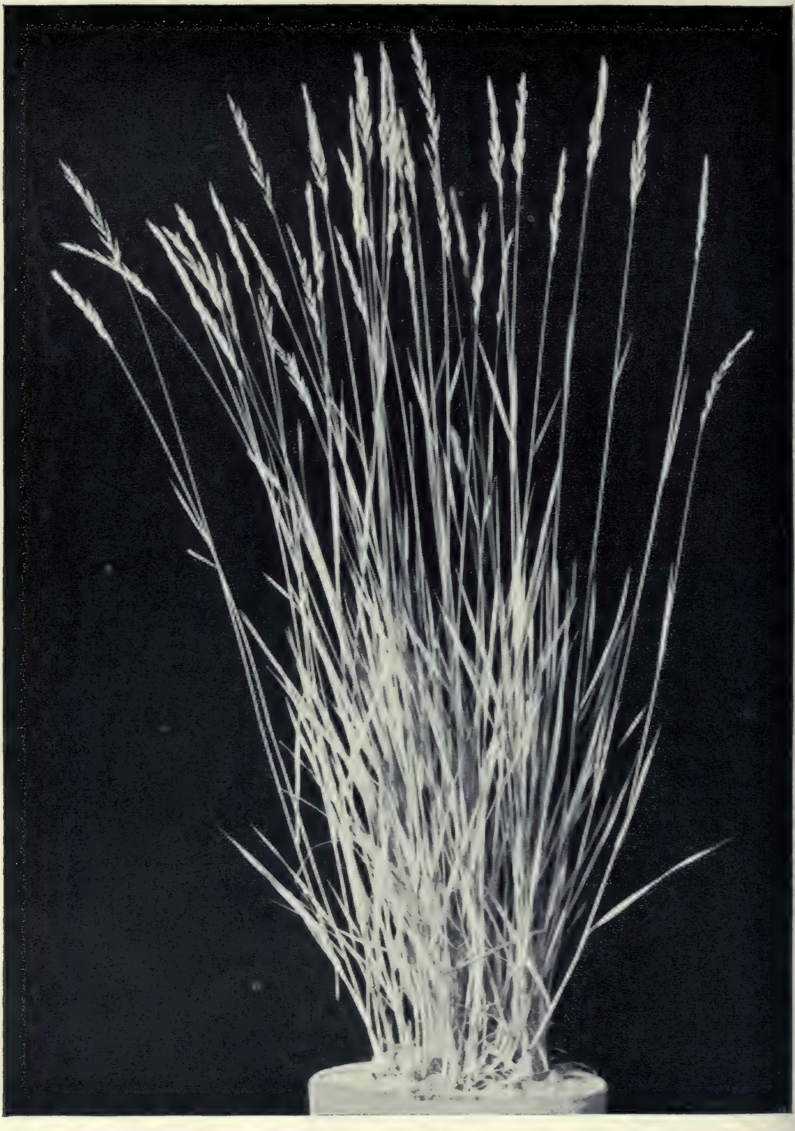


Figure 2.—Western wheatgrass produces a quick ground cover and a heavy sod over its wide range. Height, 30 to 36 inches.

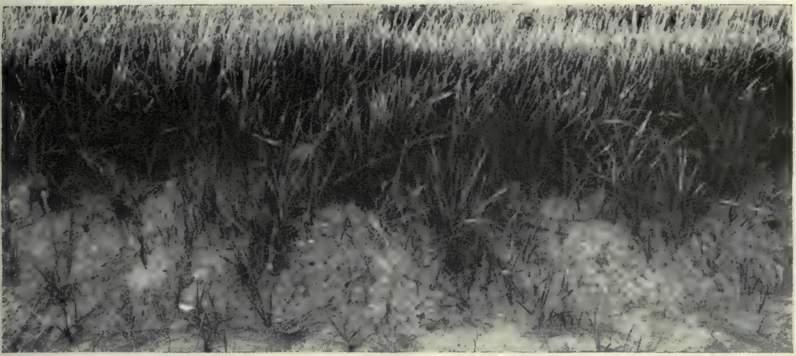


FIGURE 3.—Western wheatgrass in a native stand, spreading by rootstocks. Present height, 12 to 18 inches.

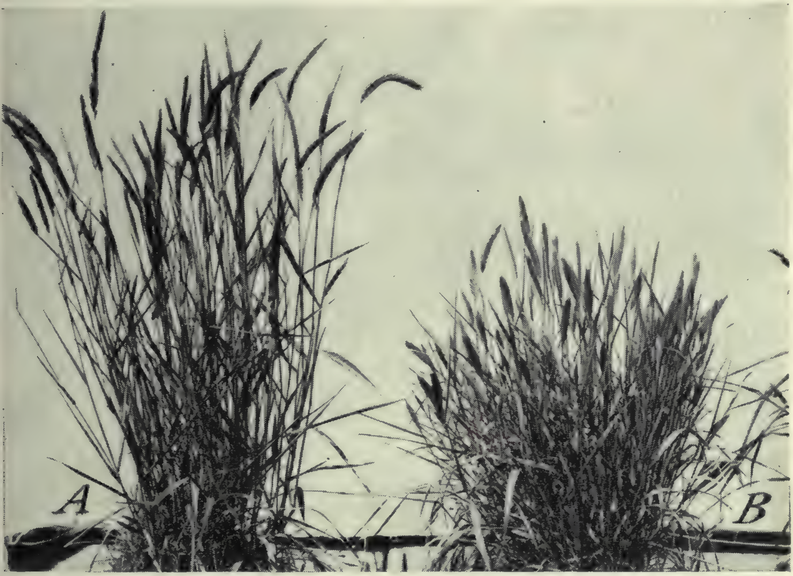


FIGURE 4.—Crested wheatgrass: *A*, A drought-resistant, winter-hardy perennial that is particularly well adapted to the northern Great Plains. Height, 24 to 30 inches. *B*, Fairway strain. This is a valued forage plant because of its leafy early growth. It is widely used as a golf-course and lawn grass. Height, 12 to 18 inches.

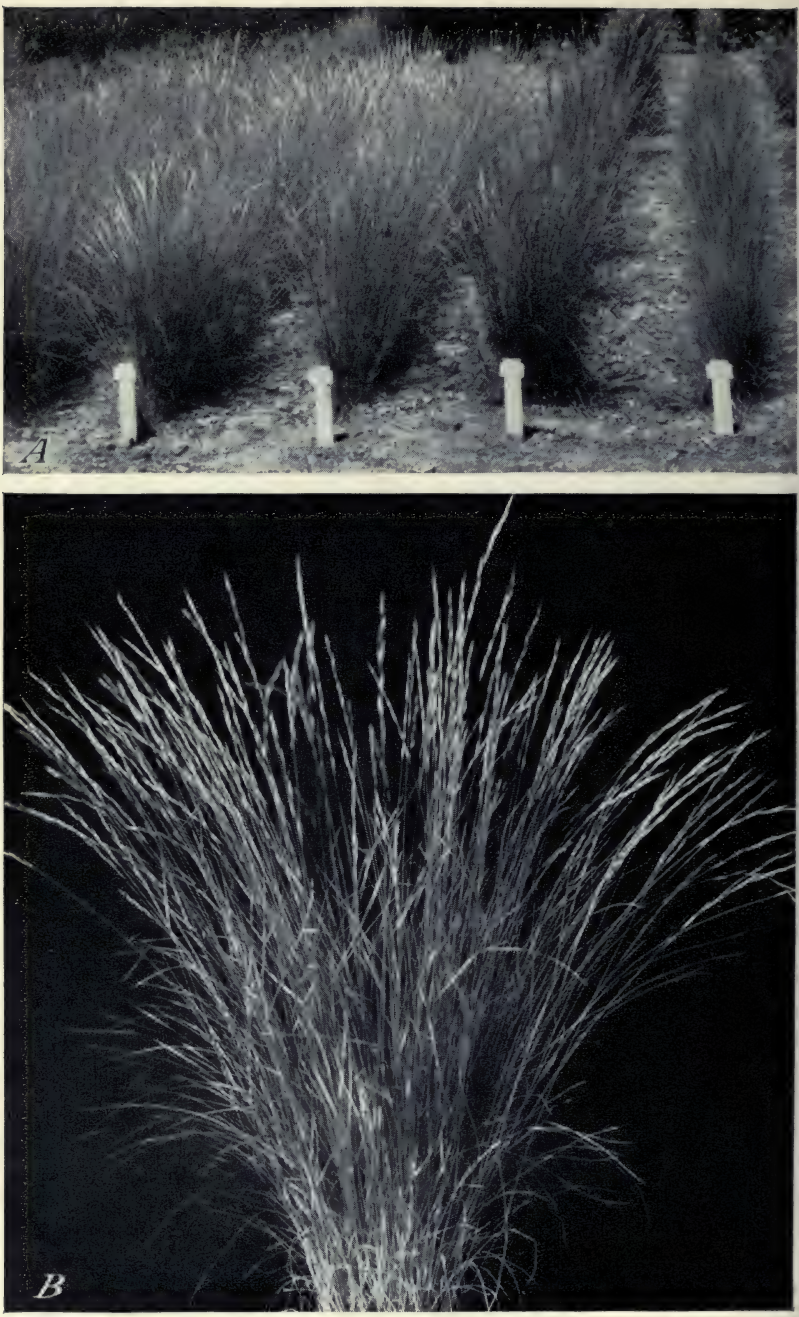


FIGURE 5.—*A*, Selections of bluebunch wheatgrass grown for observation at the Pullman, Wash., grass nursery. Each selection shows distinctive growth characteristics. *B*, Extensive stands of this grass, a native bunch grass of the Pacific Northwest, covered the virgin prairies of the Palouse section.

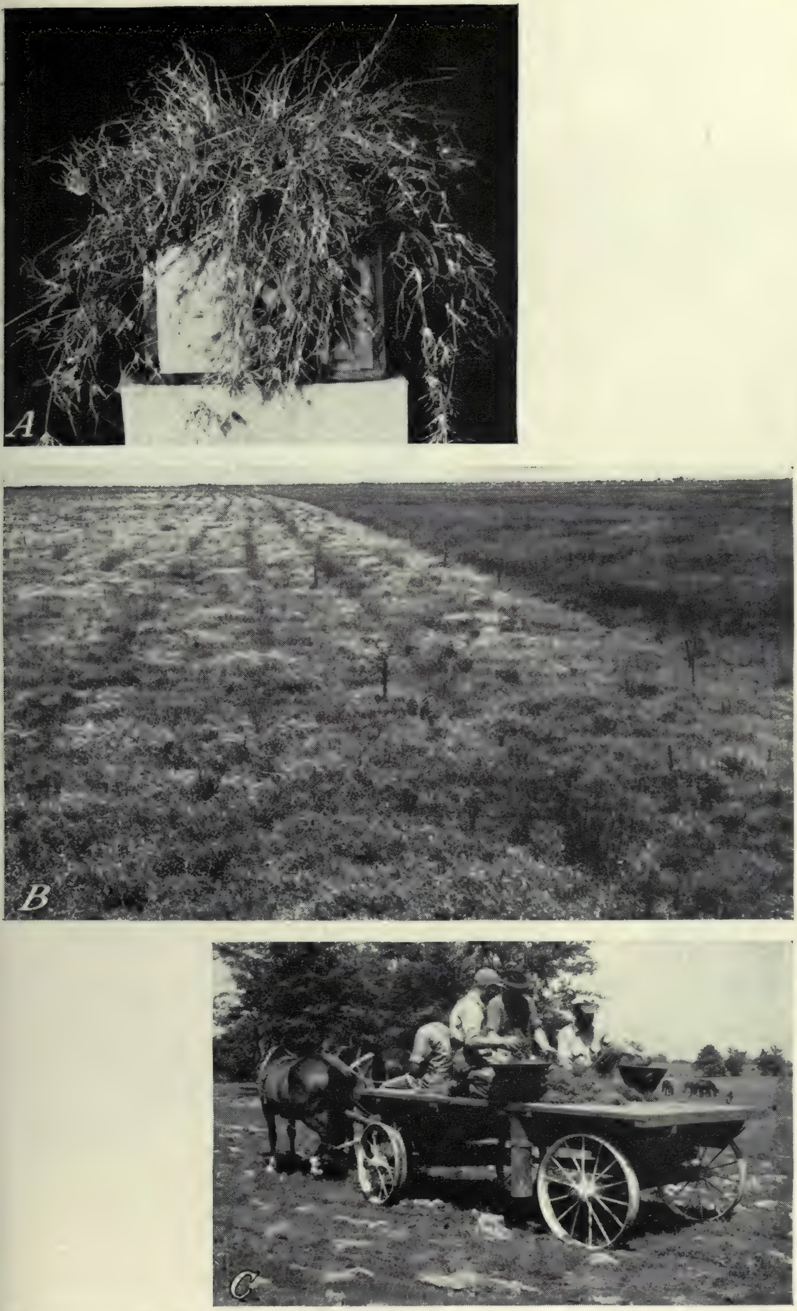


FIGURE 6.—Buffalo grass is a native perennial sod former, characteristic of the short-grass vegetation of the semiarid Great Plains. *A*, An individual plant. *B*, The area at the left has been disk-plowed, as shown by the regularly recurring narrow strips of uncut sod. Blue grama plants are concentrated in these undisturbed strips. On the extreme right is undisturbed native sod. *C*, Blocks of freshly cut sod quickly establish a dense cover.

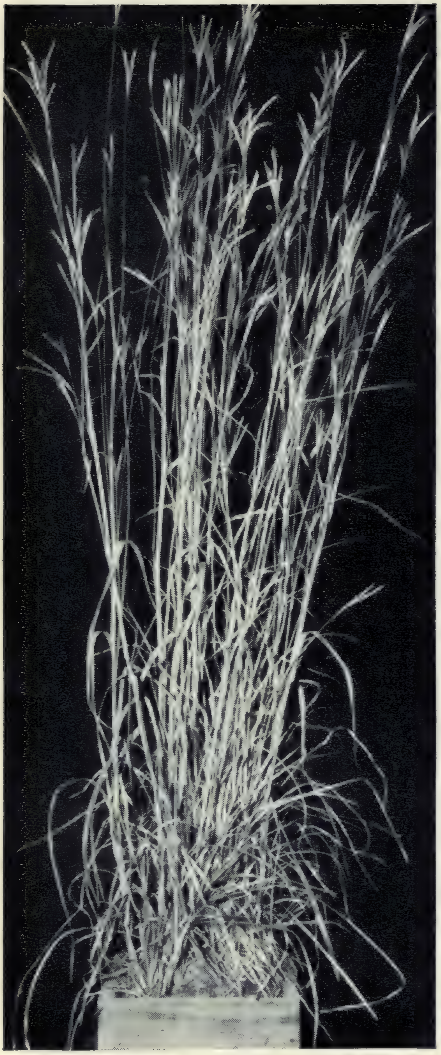


FIGURE 7.—Big bluestem, a native perennial bunch grass common in the mixed prairie vegetation of the central Great Plains. Height, 36 to 48 inches.

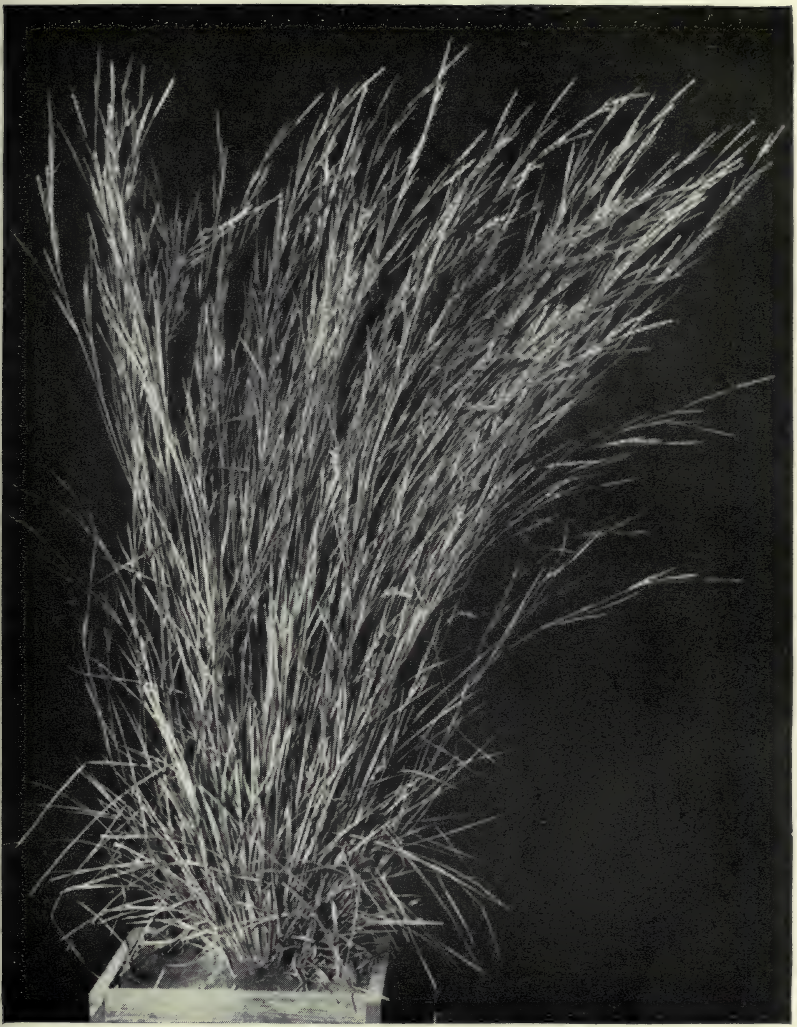


Figure 8.—Little bluestem, a native perennial bunch grass that grows over a wide range in the central Great Plains. Height, 24 to 30 inches.

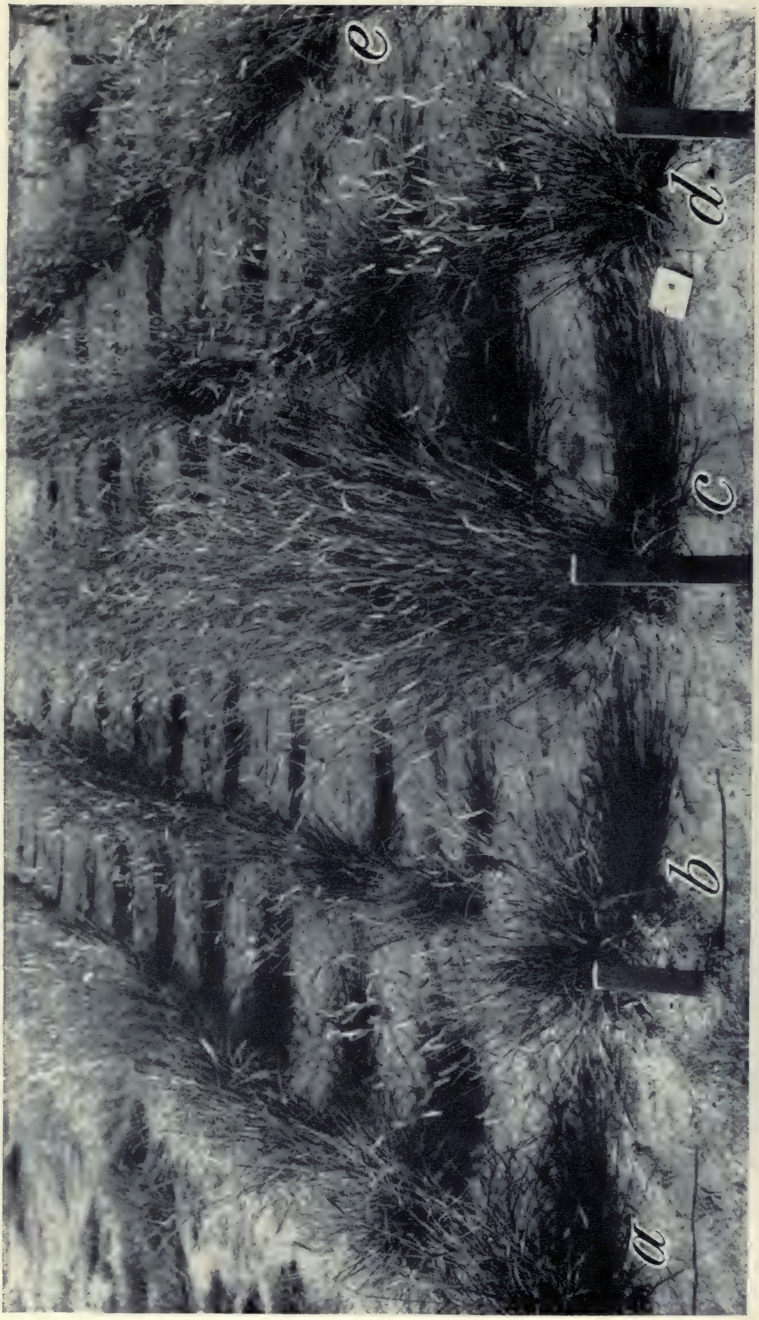
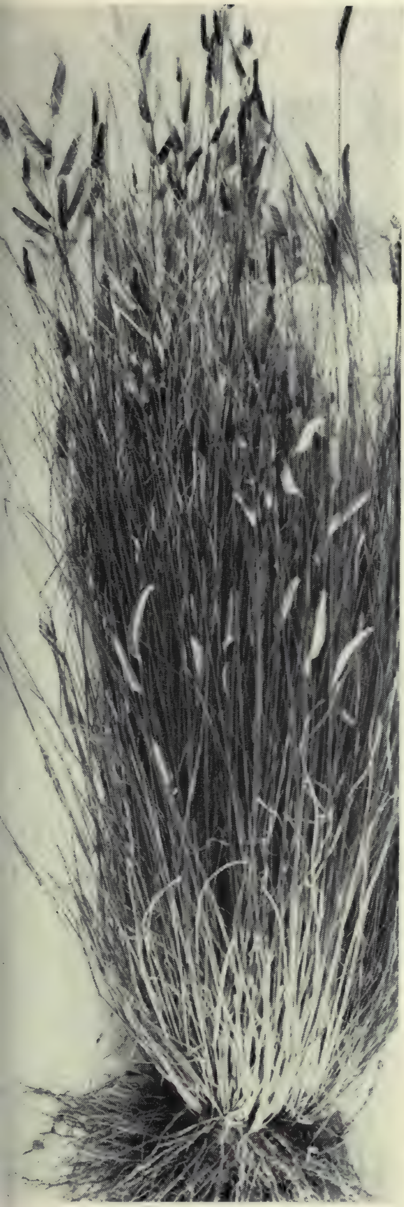


FIGURE 9.—Observational plantings of blue grama at Lincoln, Nebr., produced from seed obtained in Oklahoma (*a*), Colorado (*b*), New Mexico (*c*), Nebraska (*d*), and New Mexico (*e*).



IGURE 10.—Blue grama, a drought-resistant forage plant, widely distributed throughout the semiarid Great Plains. Height, 18 to 24 inches.

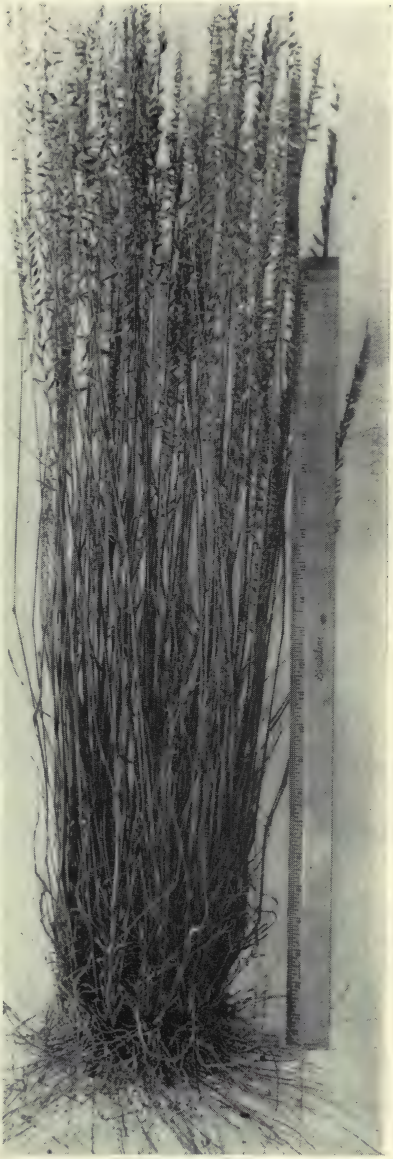


FIGURE 11.—Side-oats grama, a native perennial distributed generally throughout the Great Plains. This grass produces abundant seed and forage on dry sites. Height, 24 to 30 inches.

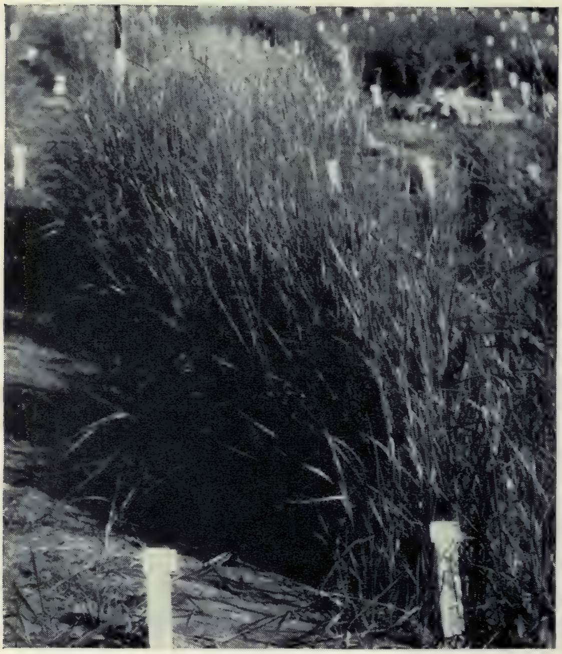


FIGURE 12.—Beardless wild-rye, a sod-forming grass that produces a good ground cover.

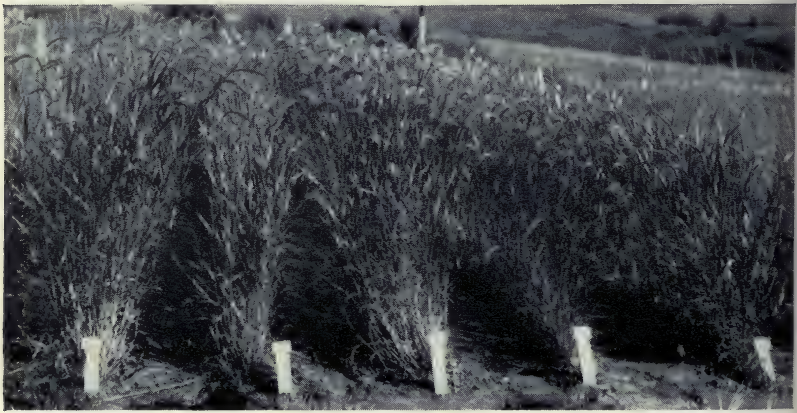


FIGURE 13.—Five strains of Canada wild-rye under observation at the Pullman, Wash., nursery. These strains, selected from native stands, show wide difference in growth characteristics.

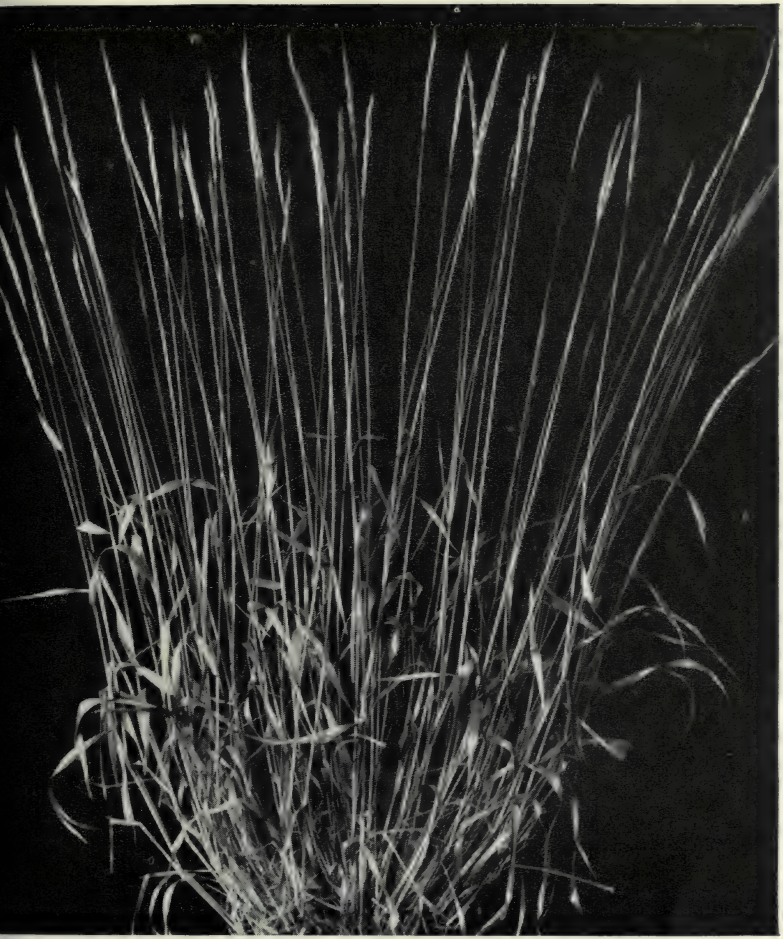


FIGURE 14.—Blue wild-rye, a vigorous, rapid-growing native grass of the Pacific Northwest. Height, 36 to 48 inches.

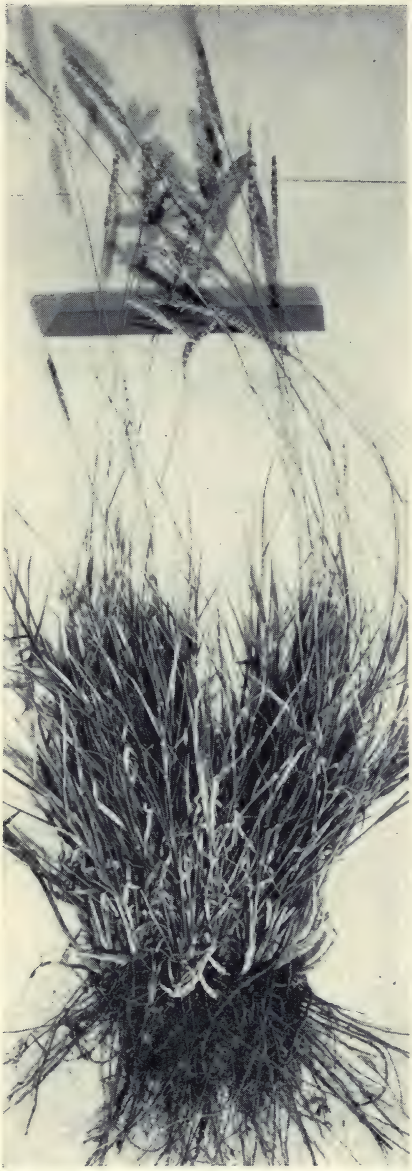


Figure 15.—Tobosa grass covers vast areas of the semiarid Southwest. It is best adapted to heavy soils that are occasionally flooded. Height, 21 inches.

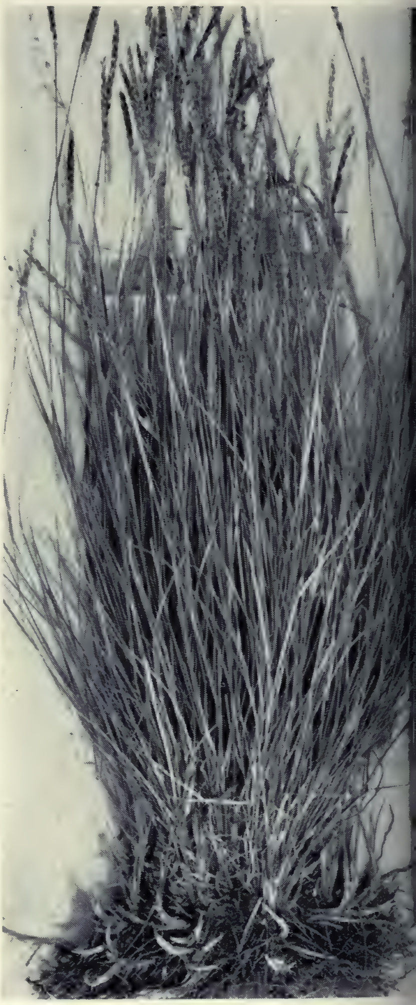


Figure 16.—Galleta grass thrives in the Southwest. Adaptation to areas of low rainfall is an important conservation characteristic. Height, 20 inches.

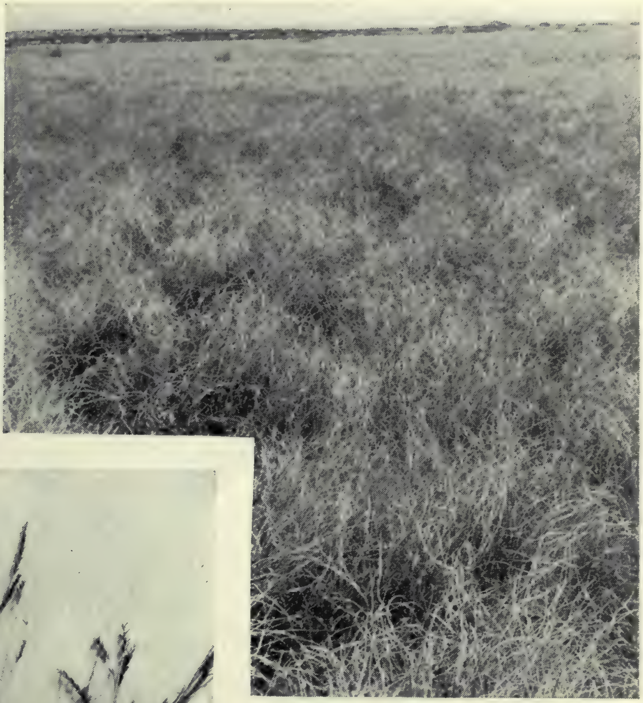
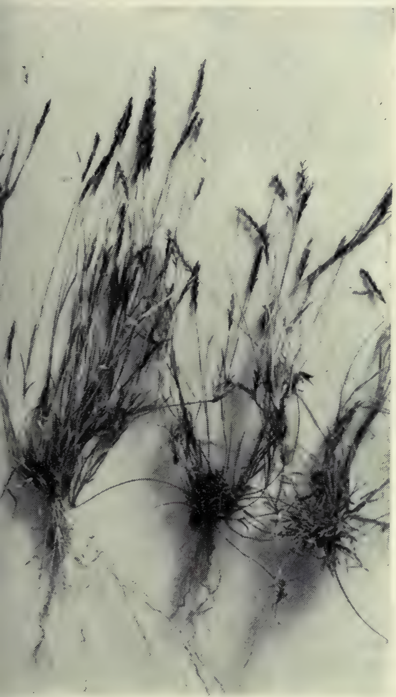


FIGURE 18.—A native stand of Tobosa grass.



URE 17.—Curly mesquite, a native erennial of the semiarid Southwest, an excellent conserver of soil and oisture. Height, 12 inches.

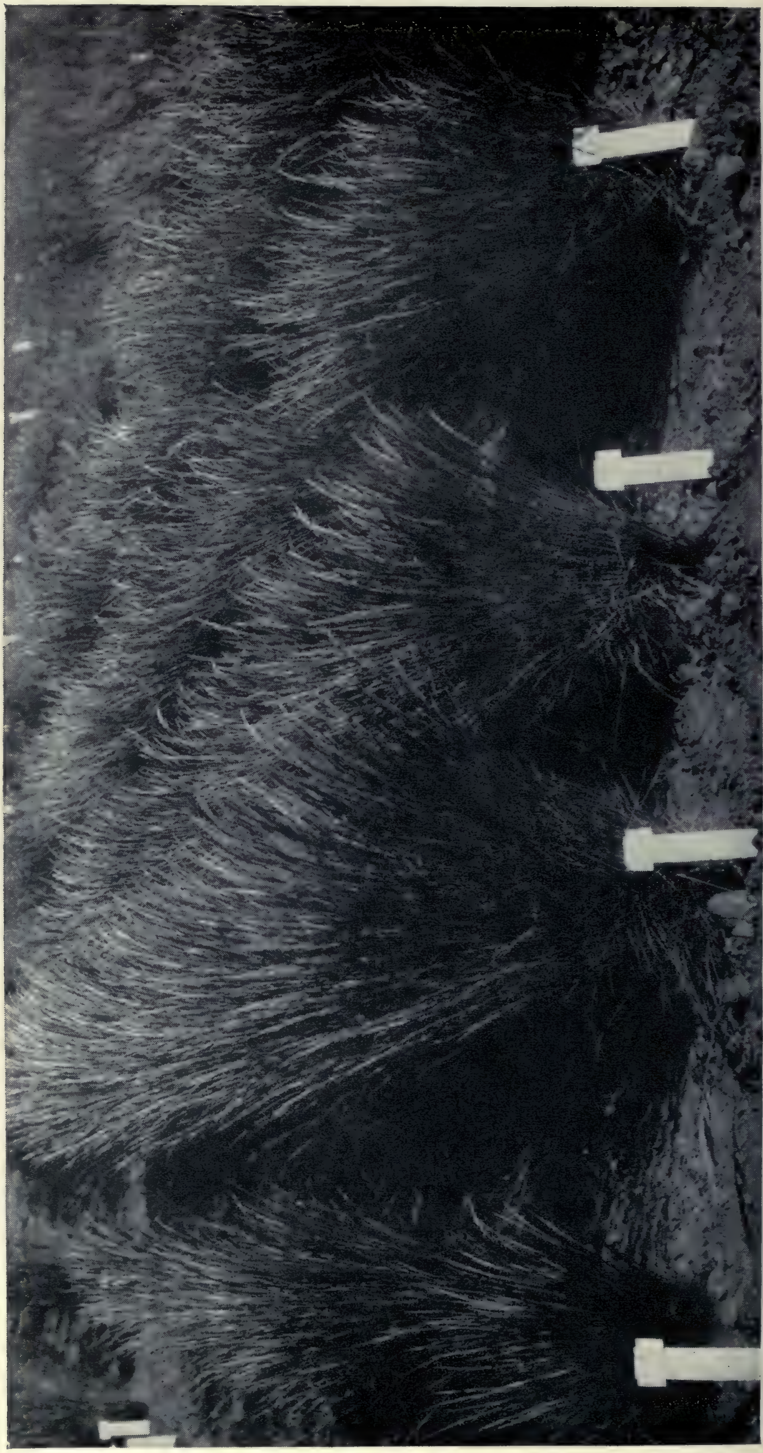


FIGURE 19.—Big bluegrass. Four strains growing in the Pullman, Wash., nursery, selected from native stands in the Pacific Northwest.

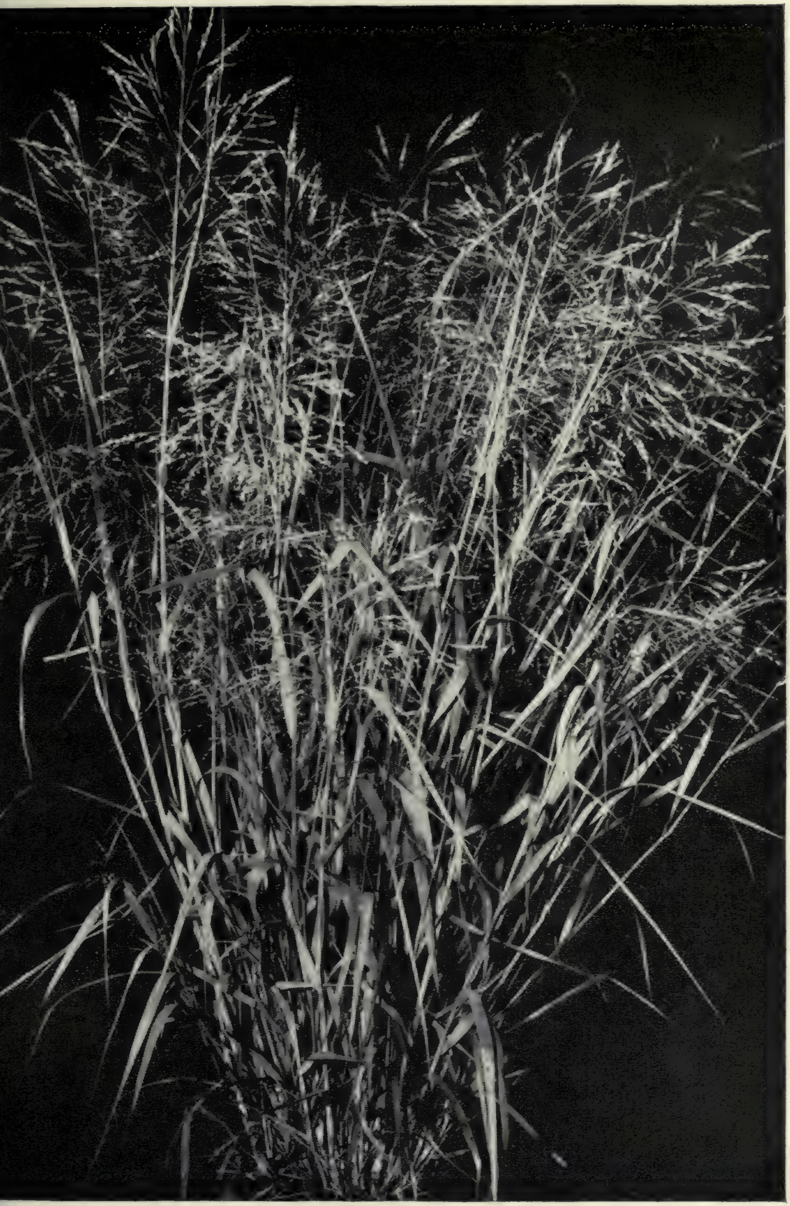


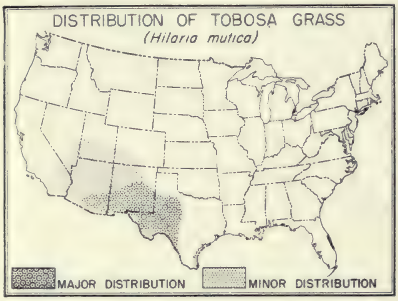
FIGURE 20.—Switchgrass, a native perennial, occurs plentifully throughout the Great Plains. This grass has excellent seeding habits and rapid, vigorous growth. Height, 36 to 48 inches.

HILARIA

Hilaria is a small genus of grasses especially adapted to the semiarid Southwest. These grasses have high value in the soil and moisture conservation practices of this region.

TOBOSA GRASS

Tobosa grass (*Hilaria mutica*) (fig. 15) is most extensive in southern Arizona and New Mexico and in western Texas. A strongly tufted perennial, it is confined chiefly to heavy soils, especially in swales that are occasionally subjected to floodwaters (fig. 18). Tobosa grass withstands grazing, but is relatively unpalatable after maturity because of the retention of dead leaves from one winter season to another. The new growth, however, supplies excellent forage before it becomes tough and woody. It is a good soil-binding plant, and its value in erosion control is augmented by the accumulated mass of dead foliage, which furnishes an excellent protective cover.

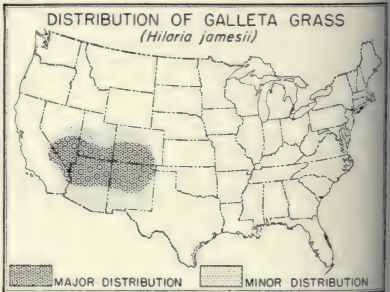


Seed can be harvested from native stands by the use of power strippers. The seed, like that of galleta grass, shatters readily and must be gathered at just the proper time if the seed is not to be lost.

GALLETA GRASS

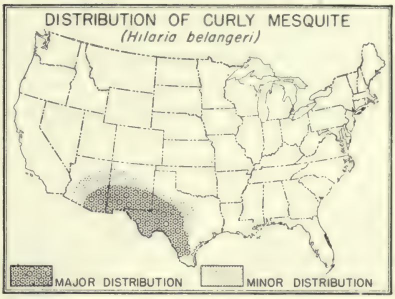
Galleta grass (*Hilaria jamesii*) (fig. 16) grows most abundantly in the western half of the Texas Panhandle, westward through Colorado, New Mexico, the northern half of Arizona and Nevada into California.

Galleta is a perennial grass with strong, scaly rootstocks and a deep, tenacious root system, which give it excellent soil-binding properties. It is one of the best forage grasses throughout its range, particularly in that it is resistant to heavy grazing and recovers rapidly when given protection from overgrazing. Seed is readily collected by machinery from native stands, but is subject to severe shattering, which necessitates watchfulness to prevent loss of the seed crop. Yields of 20 pounds per acre have been obtained. Since the percentage of filled seed is rather low, a seeding rate of about 10 pounds of uncleaned seed per acre is required. Under range conditions seed is sown broadcast and either covered lightly or left to come up naturally. Young seedlings are very drought-resistant and winter hardy.



CURLY MESQUITE

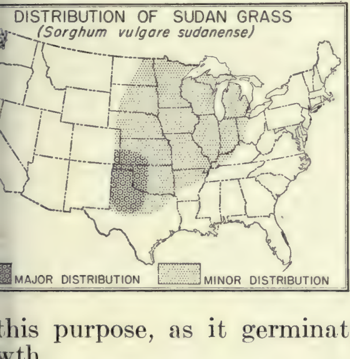
'urly mesquite (*Hilaria belangeri*) (fig. 17) is a range grass that ws rather generally throughout southern New Mexico and Arizona occurs also in scattered stands r wider areas of the Southwest. ; sometimes confused with buf- grass, with which it is frequently ciated and which it resembles. ly mesquite is a perennial that ws in loose tufts or clumps and oduces both by seed and slen- stolons.



s tufted stoloniferous habit, ch gives it excellent soil-binding perties, its resistance to drought, its aggressiveness under heavy zing make it one of the best erosion-control grasses of the Southwest. he plants are indeterminate in growth and produce seed rather ingly throughout an extended period. There are two periods of imum seed production, however, the first in early summer and second after rains in early fall. Hand methods of collecting the l have generally been used since the grass usually grows on rocky, ply sloping land. But in certain localities the stands are dense ugh and the land sufficiently level to permit satisfactory use of hinery. In view of this fact seed production under cultivation is ssary, and methods of growing the grass for this purpose are g studied at the nurseries.

SUDAN GRASS

udan grass (*Sorghum vulgare* var. *sudanense*) was introduced from th Africa in 1909. It resembles Johnson grass in general appearance, but, being an annual and lacking rootstocks, it does not become troublesome as a weed. Adapted to the same general soil and climatic conditions as sorghum, it has been grown with success practically throughout the United States. Extensive plantings have been made in the semiarid region of the Great Plains, especially in the "Dust Bowl," to assist in stabilizing soils susceptible to wind erosion. Sudan grass is one of the plants best suited this purpose, as it germinates quickly and makes rapid, sturdy wth.



'he usual procedure in establishing the grass is to blank-list the ling field and leave the plant stubble in place at the end of the season as a protective cover during the winter. Seedings the followi spring are made in the plant residue, which serves to protect t young seedlings until they become well established.

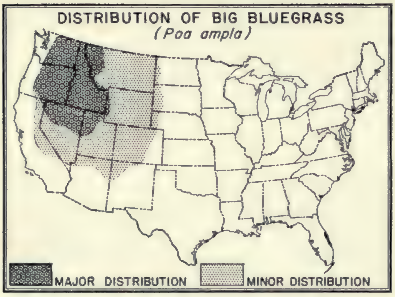
Sudan grass is used extensively as a supplementary pasture a forage crop in important dairy centers. It also provides food a cover for birds. Seed is produced abundantly throughout t semiarid parts of the Great Plains. This grass is most useful in t agricultural economy of this region because of its extreme droug hardiness and adaptation to a wide variety of soils.

BLUEGRASS

The bluegrasses compose a large and economically important grou which is well represented in the United States. The more importa of the native species are perennial and occur chiefly in the Paci Northwest and Rocky Mountain regions.

BIG BLUEGRASS

Big bluegrass (*Poa ampla*) is the most important of a group native bluegrasses common to the Western States. Although seldo found in dense stands, it is one of the most valuable range grasses the intermountain region of t Pacific Northwest because of i heavy forage production, high pa atability, and tendency to resum early spring and fall growth. Th species is very drought-resistan Because of its wide distributio dense, extensive root system, hea foliage, and adaptation to adver sites and climates, it is one of t outstanding erosion-control grass



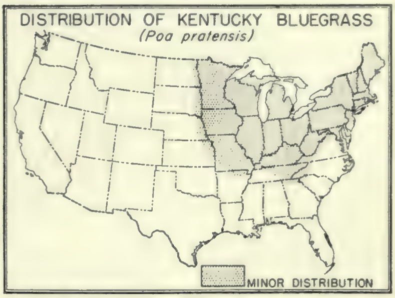
The seed is large and is ordinari produced in abundance, but sin the plant reproduces only by seed it is necessary to adopt rang management practices that will permit natural seeding to take plac Overgrazing and severe trampling are injurious to native stands this grass, and, without proper protective grazing, a range will dete orate rapidly.

Plants under observation at grass nurseries (fig. 19) show differenc in seed, foliage, and growth characteristics, and marked improveme has been obtained by selection of plants having superior yield a value for erosion control.

KENTUCKY BLUEGRASS

Kentucky bluegrass (*Poa pratensis*) and Canada bluegrass (*P. co* *pressa*) are introductions from the Old World that have becon naturalized and are present generally in the cool, humid norther half of the United States east of the 99th meridian. These grass are also found on the west slope of the Cascade Mountains of t Pacific Northwest and at higher elevations throughout the Rock untains wherever satisfactory temperature and moisture are sent. It is significant to note that more than 20 years ago the est Service considered Kentucky bluegrass as one of the 10 most ortant grasses in Oregon and Washington.

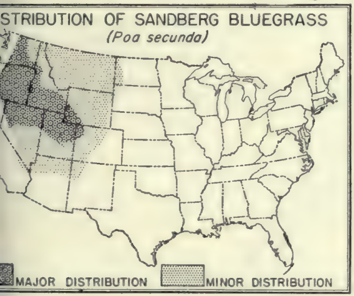
oth of these grasses form a dense, tough sod, capable of withding trampling by livestock. In the past it was thought that ntucky bluegrass would grow only on limestone soils, but it is now lerstood that it is fertility ler than lime that is essential. ada bluegrass is more droughtstant and is adapted to less fer- soils than Kentucky bluegrass. oth of these grasses are highly table and withstand grazing. s and their excellent seed and -forming habits make them very ful for erosion control. They be adapted to terrace-channel gully seedings if establishment y seed and sod. The procee followed in establishing these grasses by sodding is similar to t already described for some of the native grasses.



eed of Kentucky bluegrass is grown commercially in the Ohio ley and upper Mississippi Valley; that of Canada bluegrass is duced largely in Ontario and New York State.

SANDBERG BLUEGRASS

andberg bluegrass (*Poa secunda*) is common throughout the thern Great Plains, but the area of major distribution is in the rmountain region and Pacific Northwest. It is a perennial bunch grass that supplies a major part of the range forage during the early spring and remains dry and dormant the rest of the season. It is very drought-resistant and comes up and persists on semidesert and scabland where other native grasses have disappeared. This persistence is largely due to the fact that the plant is exceptionally deep-rooted and thus able to withstand trampling by livestock. Growth and seed production take place dur- the early season, when moisture conditions are favorable. The ess leafage produced at this time remains palatable throughout season, and this plant therefore contributes to the carrying capac- of many of the ranges of the Northwest.



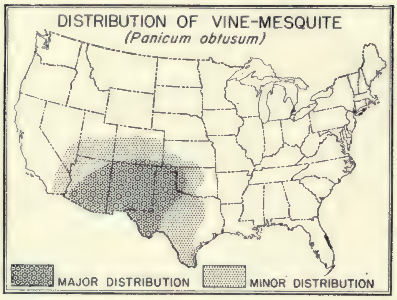
andberg bluegrass produces a fair amount of seed; with proper nagement the stand can be maintained indefinitely. Seeding ls made thus far under controlled conditions indicate that it is icult to establish this grass from seed.

PANIC GRASSES

The panic grasses are very numerous and are found chiefly in t warmer regions of the world. This group is very well represented the United States, but only two species are being used extensively the conservation program.

VINE-MESQUITE

Vine-mesquite (*Panicum obtusum*) is found generally in weste Texas, Arizona, New Mexico, and southern Colorado. It forms characteristically viny growth and occurs more commonly on goo soils that have more than the normal amount of moisture.



The creeping runners grow very rapidly. They take root at t nodes, anchoring themselves tightly to the ground, and produce ne plants. They quickly form a den soil-binding mat, which makes t vine-mesquite a particularly valu ble erosion-control plant. It repr duces not only by creeping runne and by rootstocks, which tran plant readily, but also by see But since it requires considerab moisture and does not thrive on soil types, it finds its best use lining for drainageways and as pr tective bank cover.

Successful vegetative plantin have been made by transplanting rootstocks or suitable pieces of so The greatest success has been reported when this work was done early spring during periods when moisture and temperature were mo favorable.

Seed of vine-mesquite has been harvested successfully with pow strippers and also by cutting the grass as hay and threshing. But t seed collected from natural stands is usually of low quality and do not germinate well. During some years native stands are heavi infested with ergot, which further lowers the quality of the seed.

SWITCHGRASS

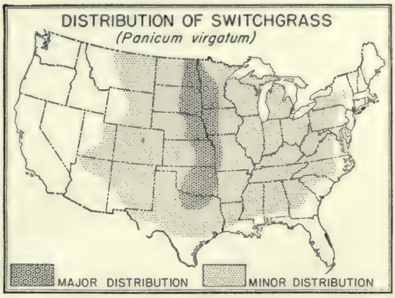
Switchgrass (*Panicum virgatum*) (fig. 20) is a native perennial th occurs widely throughout the United States but reaches its greate usefulness in the Great Plains.

This grass develops extensive rootstocks and produces an abundan of leafy forage, which makes a hay of acceptable quality if cut at t proper stage of growth. If switchgrass is grazed, the excess folia soon becomes harsh, woody, and unpalatable to livestock, although continues to supply abundant ground cover. The old stems an leaves remain standing throughout the winter. They offer protectio against wind and serve as a natural barrier to snow and soil driftin This special quality, in addition to deep-rooting and vigorous roo stocks, makes this an outstanding grass for use in erosion contro

:ted strains grown for observation at the grass nurseries of the Conservation Service show marked differences in resistance to shoppers and rust. Resistance to insects and disease makes it ıer dependable for conservation use.

ritchgrass is used in the northern Great Plains in planting contour s as a protection against wind and water erosion. The old plant ue left in place provides a very tive snow trap and ground cover ıg the winter.

ed has been satisfactorily col- d from native stands by using er strippers, although under nat- conditions the seed usually ains varying amounts of big stem, Indian grass, and other ciated tall prairie grasses. Ex- nt yields of pure, good-quality also have been obtained at nurseries when this grass was n in rows spaced 30 inches apart to permit cultivation. When grass was planted in rows seeding at the rate of 6 to 8 pounds per gave excellent stands, but 15 or 18 pounds was required when was broadcast or drilled.

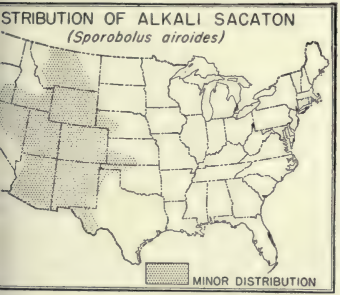

DISTRIBUTION OF SWITCHGRASS
(Panicum virgatum)

DROPSEED

ıe dropseeds belong to a large group of grasses that receives its non name because of the promptness with which the seed is shed ripening. Several of these grasses are adapted to the climatic soil conditions of the Great Plains and the Southwest, where can be used widely in erosion control.

ALKALI SACATON

kali sacaton (*Sporobolus airoides*) is very common in all States west of the Mississippi River and, as the name indicates, is especially resistant to alkali soils. It is a large perennial bunch grass, which produces a fair quality of hay if cut at the proper stage of development. If allowed to mature, the plants become woody and more or less unpalatable either for hay or grazing.

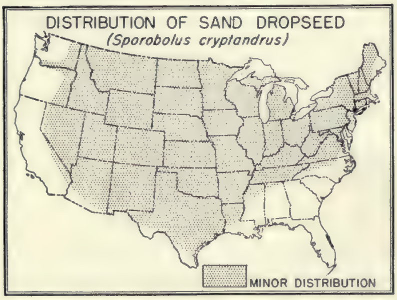

STRIBUTION OF ALKALI SACATON
(Sporobolus airoides)

The seed is easily collected in quantity from native stands with power strippers or by threshing the ced hay and can be used without further cleaning. Although of excellent quality has also been produced at the grass nurs- , where unusually heavy yields have been obtained, it is not ssary that seed of this grass be produced under cultivation, since its general distribution insures a good seed crop every season so where within its range.

This native grass is very desirable for general use in revegetat particularly on highly alkaline soils, because of its heavy foli deep root system, drought-resistant properties, and ease of seedi

SAND DROPSEED

Sand dropseed (*Sporobolus cryptandrus*) is distributed gener throughout the United States, but is especially well adapted climatic conditions in the States west of the Mississippi River. I an important constituent of native grasses of the Great Pl and, as the name "sand dropse indicates, is commonly found sandy soils. It produces ra heavy forage that is fairly palat to all classes of livestock, but is necessary to avoid destroying stand by overgrazing. This g recovers rapidly, however, owin its excellent seeding habits.



Sand dropseed is easily harve by power strippers. Since the se shatter readily, the material obtained from the strippers is often cl enough to be seeded directly with farm equipment. Scarifying the s makes good germination much less difficult to obtain.

Sand dropseed is among the first grasses to appear naturally unused farm lands, and it provides effective cover until replaced b more valuable crop. It is well adapted to seeding in mixture w other native grasses. Seeding at the rate of 2 pounds per acre given a satisfactory cover.

NEEDLEGRASS

The needlegrasses are world-wide in distribution and are represented in the native flora of the western United States.

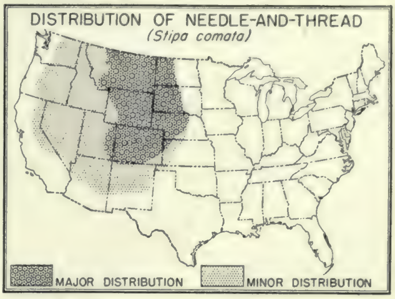
Although individual species differ widely in their relative usefu for forage and erosion control, the group as a whole supplies abund feed and vegetative cover in many of the principal range ar Range men hold different opinions as to the value of some of t grasses, some saying that the heavily awned seed frequently ca serious harm to grazing animals.

The numerous grasses of this group are widely distributed have the ability to produce vegetative cover under extremes climate and widely different soils. Because of this wide adaptab these grasses are especially useful in soil and moisture conservat Many of them are among the pioneer species that come natur into retired farm lands, and, because of their drought hardiness ability to withstand close grazing, they are among the last to disap from a severely misused range.

As these grasses grow naturally in association with other m palatable grasses they may be seeded in mixtures for revegetat

NEEDLE-AND-THREAD

Needle-and-thread (*Stipa comata*) is a leafy bunch grass and is nmonly found throughout the Western States on dry sandy soils. produces an abundance of for-, particularly during early spring l summer. Its common name ers to the long threadlike awns ıt form a characteristic seed head. This grass is held in great esteem some range men, although others l it is more or less of a pest because ts heavy, sharp awns, which cause ury to grazing animals at certain sons. In most regions a large ount of grazing is possible early the season before the grass tures; and during some seasons very acceptable hay can be cut after seed has shattered.



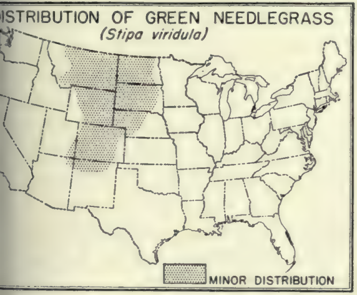
Seed of very good quality has been collected by power strippers m native stands of this grass. The heavy awns and sharp callus, vever, make collecting and threshing operations rather difficult.

n field plantings of this grass best results have been obtained from ced seedings.

GREEN NEEDLEGRASS

Green needlegrass (*Stipa viridula*) is a perennial bunch grass that is ticularly useful on the ranges of the northern Great Plains.

t is considered an excellent forage grass chiefly because it begins wth early in the season and remains green for a long period. Although the species bears abundant awns they are short and slender and not as objectionable as in some of the other needlegrasses.



Seed of green needlegrass has been collected from native stands with power strippers; when obtained in this manner, the seed is usually mixed with that of other associated grasses.

Seed produced under cultivation has been excellent in yield and quality. Observational plantings, howr, indicate wide differences in selections obtained from various rces, not only in yield of seed and forage but also in percentage of mination and growth habits.

Newly emerged seedlings of green needlegrass have been found to be istant to drought and injury from sand cutting. This ability to hstand extremely unfavorable conditions during the period of ablishment makes this species one of the most useful native grasses include in seed mixtures used for revegetation.

SPECIAL EQUIPMENT USEFUL IN PLANTING NATIVE GRASSE

The extensive use of many of the stoloniferous or sod grasses revegetation operations has called for special methods of planti Both Bermuda grass and buffalo grass have been successfully hand by the method illustrated in figure 6, C. Establishment of these types appears to be depend upon placing the stolons in f contact with fresh soil, and it most successful when the tra planting was done in early spr just preceding the growing peri

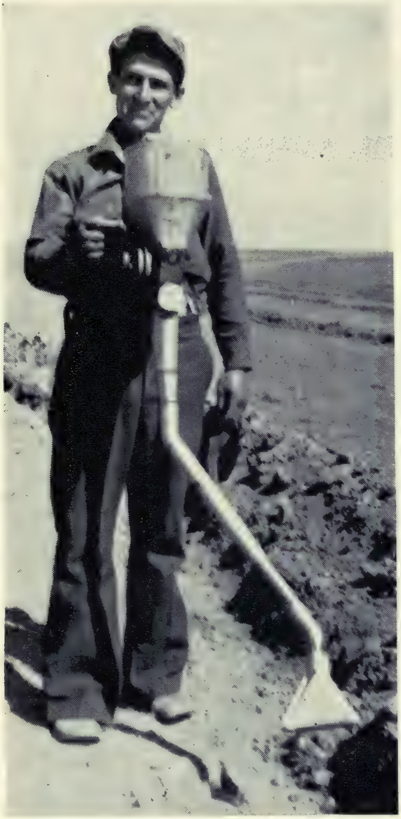


FIGURE 21.—Hand-operated native-grass seeder, constructed from ordinary crank-operated duster. This equipment can be used effectively on windy days and permits even seed distribution.

Seeding equipment now availa for drilling grass seed is not suited to the seeding of native s cies. Most native seed is fl and light and, therefore, cannot fed evenly through present ty of drills. A more fundamental d culty concerns the depth of pla ing and method of covering. M native grasses require a well-firm seedbed and should not be cove more than ½ to 1 inch in dep Many attempts have been made design equipment to meet these quirements, but as yet no mach entirely satisfactory has been veloped.

A hand seeder useful in seed native grasses on contour furrow illustrated in figure 21. This chine has been constructed by m ing a few changes in an ordin crank duster, and by using an tension tube and spreader it is p sible to make contour seedings windy days.

The lister device illustrated figure 22 has been used in cert parts of the Great Plains in mak contour seedings of native gra on abandoned farm lands. This chine has a distinct advantage that the seeded area is left ridged after being seeded, and in regi of scant moisture this is a very important factor in determining success or failure of the seeding operation. A cotton-type plant box equipped with a properly regulated shoe to control depth planting and a suitable packer wheel makes this equipment useful for seeding most of the grasses used in the central Great Pla

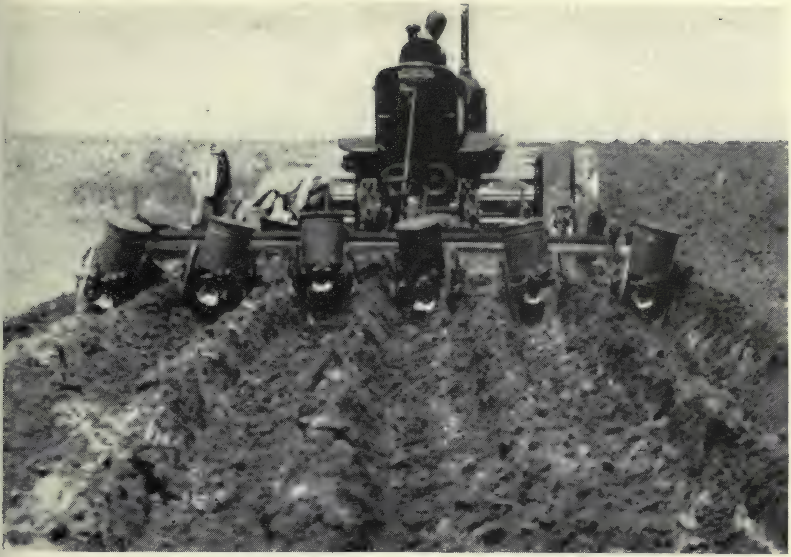


FIGURE 22.—Special lister designed to plant native grass seed in contour furrows. This type of equipment is particularly useful in the semiarid parts of the Great Plains.

SPECIAL EQUIPMENT USED IN THE COLLECTION AND CLEANING OF NATIVE GRASSES

The wide use of grass for conservation of the soil has entailed the levising of methods of collecting, cleaning, and seeding native grass eed never before harvested. Farm machinery has been put to new ises, and new equipment has been designed.

GRASS KNIFE

A simple but very effective aid in the hand collection of certain of he native grasses is a curved knife with a 6-inch cutting blade that an be constructed from any scrap steel that will retain a good cutting dge when sharpened.

In using this knife laborers carry bags strapped to their waists or cross their shoulders and place each handful of grass in the bag as it s cut. When the bag has been filled, the strap is loosened and attached to an empty bag. Hooks on the strap facilitate this exchange f containers.

The tool is especially adapted to collecting bunch grass in scattered tands. The amount of little bluestem seed each man harvested vas increased from 125 to 200 pounds per 8-hour day when this grass knife was substituted for the knives previously used.

BLUEGRASS STRIPPER

The commercial revolving spike-cylinder seed stripper commonly ised in harvesting cultivated grasses, particularly bluegrass and neadow fescue, has proved very satisfactory for use in the collection f many of the native grasses. Hooked in tandem, such a unit has

been used most effectively to collect blue grama seed on 25 to 3
acres in a normal working day.

POWER STRIPPERS

In collecting seed of the native grasses in quantity it is necessary t have equipment that will operate on the rough ground on whic many of the grasses are found and collect the seed rapidly before i becomes overripe and shatters. Power strippers designed on th principle of the commercial spike-cylinder bluegrass stripper mee both these requirements.

The earliest of these power strippers (fig. 23, *A*) consisted of revolving spiked cylinder and seed box mounted on a frame an carried on a truck chassis. The cylinder of this stripper was drive by chain and sprocket from the rear wheel of the truck chassis, wit the steering gears inverted to permit the operator to drive the machin in reverse. Made up largely of used-car parts, the machine wa crude in construction but surprisingly effective in increasing the outpu of seed per collecting unit. Such a machine was able to cover abou 25 acres in an 8-hour day.

After this stripper was used for one season, several improvement were made that greatly added to its efficiency (fig. 23, *B*). Th cylinder box was mounted in front of the truck in such a manner as t permit height adjustment from the car cab. The stripper proper i driven from the rear wheel of the truck by means of a sprocket whee chain, pulley, and belt arrangement. A commercial bluegrass stripp attached to the rear of the truck gives a total stripping swath of 1 feet. This unit also has the advantage of being readily detachabl which allows the truck to be used for other purposes.

Figure 23, *C* shows a modification of the original power stripp developed at the Tucson, Ariz., nursery being used to harvest Rothroc grama. Operated by side draft, this stripper is driven directly fro the rear wheel of the truck, and a change of cylinder speed is mad possible by means of a special gear. The cylinder, hopper box, an frame are of heavy, reinforced construction, and the stripper unit ca be dismounted and attached to the truck as a trailer. One man ca operate the machine.

GRAIN BINDERS AND MOWER BUNCHERS

Regular small-grain binder equipment can be used in harvestin the seed of some of the taller native grasses if the stands are dense o tall. If shattering is excessive the bundle-tying apparatus is remove in order to leave the cut grass in windrows for curing and subsequen threshing. Reapers have been used very satisfactorily in this sam manner in collecting seed of some of the taller grasses.

The mower buncher, which has rather wide use in the handling o some of the commercial grasses and legumes, is more useful at th grass nurseries than under range conditions, where the natural stand are less suitable for such handling.

COMBINE HARVESTERS

Combine-harvester equipment can be used effectively in areas wher the topography and type of grass permit satisfactory operation Western wheatgrass was the first native grass to be harvested i

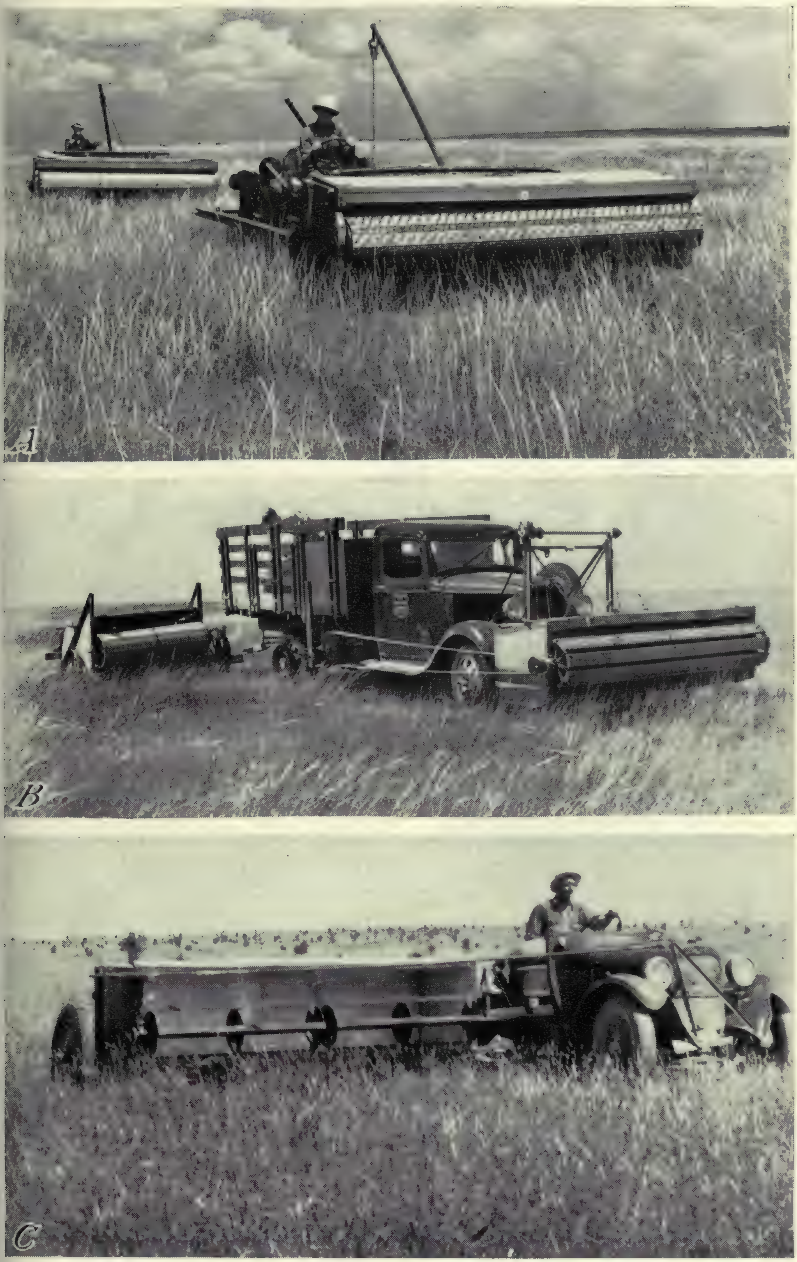


FIGURE 23.—Power strippers: *A*, Nebraska type operating in a native stand of grama and dropseed grasses. *B*, Improved Nebraska type, operating in a native stand of grama and dropseed grasses. Note the special features of height adjustment used for the spike-cylinder bluegrass stripper that is being trailed by the truck. *C*, Improved Arizona type, operating in a native stand of Rothrock grama.

quantity with this machine. The condition of the threshed se depends largely upon the skill of the operator, but it is usually nece sary for the seed to be run through a clipper fanning mill in order clean it sufficiently for satisfactory use in ordinary farm drills.

The combine harvester has been used successfully in the collecti of seed of big and little bluestem. Seed of very good quality w obtained, which required very little cleaning to prepare for fa seeding.

PROCESSING NATIVE GRASS SEED

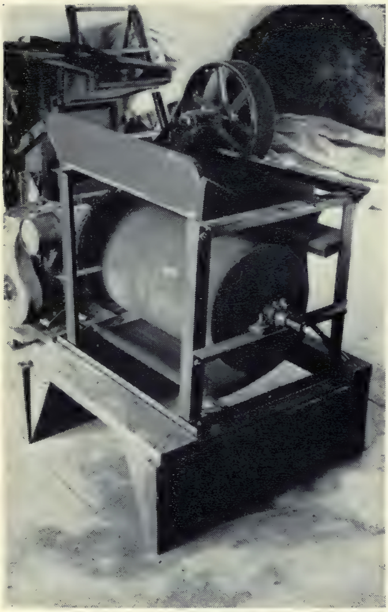


FIGURE 24.—Rubbing machine designed to remove awns and wings from light chaffy seed.

The seeds of native grasses are very difficult to clean and prepa for seeding with standard farm equipment. The light, fluffy seed certain species and the hairy glumes, sterile florets, and heavy aw of others present serious problems the mechanical processing of t seed. As the seed material com from the collection machines it common to find a fairly large pr portion of trash, straw, weed see and dirt that must be removed b fore the seed is suitable for seedin These problems of seed cleaning ha led to new uses of available see processing equipment as well as the development of new machin that are better adapted to the spe alized jobs of cleaning the seed native grasses.

Thresher-separators of the ty commonly used for threshing an cleaning small grains have be found satisfactory for the initial co centration of the seed of most nati grasses. Careful adjustments of cy inder speed, screen size, and a volume must be made to meet t requirements of each species in ord to prevent excessive losses of se during the threshing operatio Practically any of the commercial available machines can be used if proper adjustments are made an careful machine operations followed. Pneumatic tires greatly faci tate the transportation of heavy equipment and permit the use one thresher over a wide area. Machinery mounted on pneumat tires has been found particularly useful in the threshing of nati grass material that can be concentrated for threshing only at rel tively isolated locations.

Although the procedures followed in harvesting the various speci of native grasses differ widely, it has been found most economical clean the seed after it comes from the thresher. In addition to th treatment afforded by the clipper type of fanning mill many speci require also some form of mechanical scarification to remove persiste awns and glumes before the seed can be used most satisfactorily in th seeding machinery now in use on farms. Special methods of see

arification have been developed that show promise for use in the
ommercial handling of many of the native grasses.

In seeding certain native grasses the use of trashy seed material as
comes from the seed strippers and threshers without further cleaning
ppears to facilitate getting satisfactory stands. Little bluestem and
and bluestem have been successfully established by scattering over-
ipe hay containing the seed on the area to be reseeded. The straw
nd trashy material improve the moisture conditions as well as offer
dditional protection to the seedlings during the critical period of
arly establishment and growth.

Several types of machines have been constructed to assist in the
leaning of certain species of grasses that cannot be treated satisfac-
orily with standard cleaning machines. A rubbing machine was
onstructed at the Tucson, Ariz., nursery for cleaning seeds of this type.
t consists of a corrugated rubber apron that partly encloses a revolv-
ng cylinder in such a manner that tension can be applied to the seed
ow that is fed into the machine between the revolving cylinder and
pron. The rubbing effect produced by this operation is very effec-
ive in removing heavy awns and hairy, chaffy outer glumes of certain
ative grasses that cannot be cleaned with machinery that depends on
ize of screen for the separation of seeds. The capacity and efficiency
f this rubbing machine (fig. 24) have been greatly increased by
aking both corrugated rubber surfaces movable at different speeds.

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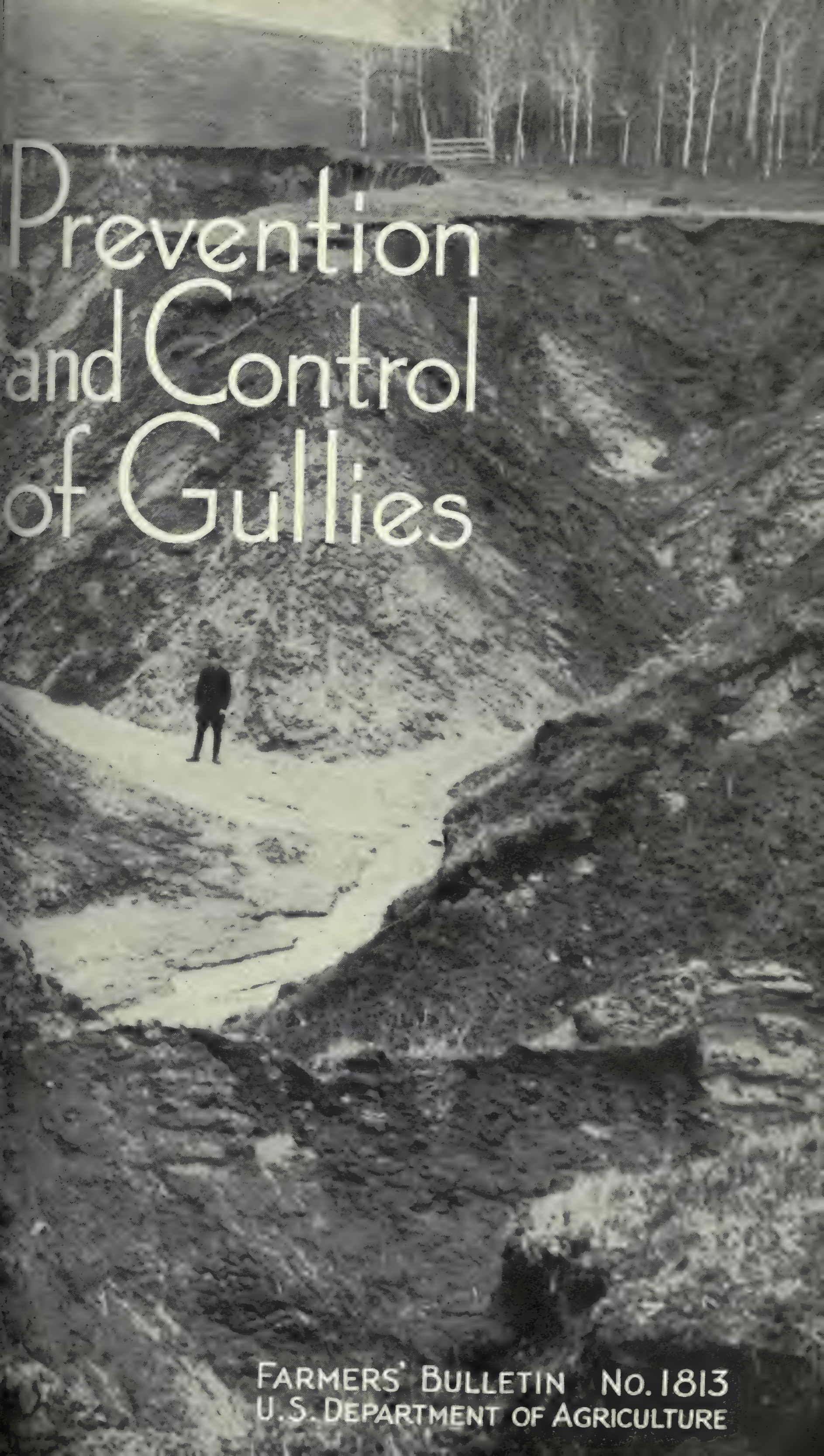
Prevention and Control of Gullies



FARMERS' BULLETIN No. 1813
U.S. DEPARTMENT OF AGRICULTURE

IT IS A COMMON CONCEPTION that gully control means building check dams, planting trees, plugging gullies with brush, or directly applying to a gully some other individual control measure. This way of thinking focuses attention on devices that stop gullies rather than on ways of farming that prevent gully erosion. It overlooks the limitations of trying to check gullies by some individual control measure and neglects the necessity of properly coordinating means of control. Uncoordinated individual control measures frequently lead to wasted effort, unnecessary expenditures, and disappointment in the performance of the controls used.

A broad, coordinated attack is in general necessary to keep gully erosion under control. A farmer who wishes to keep his fields free from gullies must give first consideration to proper land use and conservation farming on areas that contribute run-off to the gullies. He must have an understanding of the best way to take care of the run-off from those areas. He will make wide use of vegetation in replanting gullies and will therefore need information on the selection of vegetation best suited to local field conditions. He will want to know the particular uses to which plants can best be put and how vegetation can be successfully maintained.

To provide general information useful in such an approach to gully control is the purpose of this bulletin. It describes various types of treatment and states the principles that should be considered in selecting and using these means of saving the land from gullying. It shows how gully-control measures can be used effectively in coordination with recommended soil and water conservation practices.

This bulletin supersedes Farmers' Bulletins 1234, Gullies, How to Control and Reclaim Them; 1697, Using Soil-Binding Plants to Reclaim Gullies in the South; 1737, Stop Gullies: Save Your Farm; and 1760, The Use of Bluegrass Sod in the Control of Soil Erosion.

Washington, D. C.

Issued September 1939

'REVENTION AND CONTROL OF GULLIES

By Hans G. Jepson, *assistant agricultural engineer, Engineering Division, Soil Conservation Service* [1]

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WHAT GULLIES DO

SINCE THE ACHIEVEMENT of our independence, he is the greatest patriot who stops the most gullies." If this was true 0 years ago, when Patrick Henry made this statement, it is doubly ue today. For gullies are now destroying land in every State. hey have eroded many fields so badly that it has been necessary discontinue the cultivation of areas that were good farm land only few years ago. Year after year fields are abandoned as the old llies take more of the land and new ones form.

When lands are gullied, the fertile soil is carried away, and unpro ictive soil may be deposited on rich bottom lands. Reservoirs and annels are also silted up, which then have to be dredged at great pense. Gullies that cannot be crossed readily by teams and farm achinery divide fields into smaller units and thus increase the cost cultivation. As gullies tend to drain adjacent soil of its moisture, lds dry out much more rapidly near the gullies. This reduces crop elds on these fields. As these gullies become larger they branch it over the fields; and if they are allowed to develop unchecked, tire fields may have to be abandoned.

Gullies encroach upon public highways; undermine fills, bridges, id culverts; increase maintenance costs; and make travel unsafe. vestock grazing near the edge of undermined gully banks is en ingered. Gullies occasionally extend through a farmstead, under ining the farm buildings and making it necessary to remove them. he unsightly appearance of a gullied farm reduces its market value. hese destructive and unsightly ditches have already caused damage

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This bulletin has been prepared in cooperation with C. L. Hamilton and under the general supervision T. B. Chambers, in charge, Engineering Division. All members of the engineering division, and ticularly G. E. Ryerson, have submitted valuable comments and criticisms. The divisions of agronomy, dlife, and woodland management contributed to parts of the bulletin relating to their respective fields. e earlier gully-control studies of C. E. Ramser have been extensively used as well as material contributed field engineers of the Soil Conservation Service.

that amounts to millions of dollars—much of it a needless loss, h
attention been paid to the things that give gullies their start.

HOW GULLIES START

Before we destroyed the native timber, plowed up the virgin s
and allowed large herds of sheep and cattle to overgraze the ra
erosion was not a serious problem. Under nature's cover of vege
tion the soil absorbed much of the rainfall and was protected fr
excessive erosional losses.

In order to make way for the production of crops the land
cleared and plowed. No precautions were taken against loss of s
On sloping fields the rows were run regardless of the direction of
slope. As a result the amount and velocity of run-off increased u
it readily carried away large quantities of soil. At first the soil
removed from the surface in very small rivulets. They gradua
became larger, and eventually gullies were formed, which enlar
with each succeeding rain that produced run-off.

Wherever the natural protection of the land is destroyed, the
is made more vulnerable to erosion. Natural drainageways cove
with vegetation once carried the run-off from the land. Stripp
these drainageways of their natural cover and cultivating across th
(fig. 1, *A*) or subjecting them to other undesirable farming practi
is the beginning of many gullies. Steep slopes cleared for cultivat
(fig. 1, *C*) will soon be badly gullied.

Poorly placed or poorly protected outlets for farm-drainage syste
or improperly designed irrigation channels are points where ma
gullies begin. Improper location and protection of drains for fa
roads or highway systems are an invitation to a gully to take
adjacent land. Trails or ruts over sloping fields (fig. 1, *B*), a
contribute to some extent to the formation of gullies. The divers
of run-off into drainageways that are not well enough protected
carry the additional load is one of the surest ways to give gullie
start.

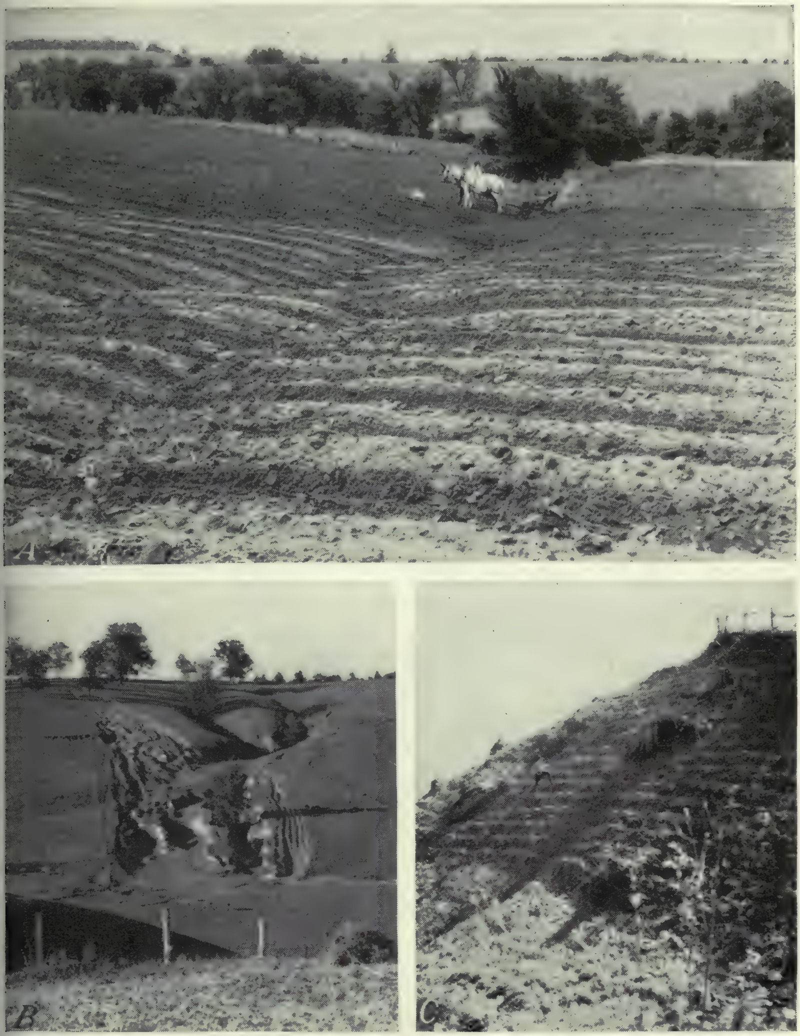
TYPES OF GULLYING

The careless use of land makes it possible for gullies to fo
Gullying proceeds by waterfall erosion, channel erosion, erosion
alternate freezing and thawing, or a combination of these three typ
Each type of gullying has a characteristic form (fig. 2), which m
be modified to a considerable extent by local soil characterist
If the underlying soil materials are soft and easily incised, de
straight-walled gullies are formed; if the subsoil consists of plas
resistant clays, the gullies are relatively shallow with sloping ban

WATERFALL EROSION

Water falling over the edge of a gully or the bank of a ditch for
deep and very rapidly extending gullies. Their characteristic form
a U-shaped cross section (fig. 2, *A*).

A small vertical overfall usually develops in the lower reaches o
drainageway, and water falling over it undermines the edge of
bank, which caves in, and the waterfall moves upstream. As
overfall advances up the slope its vertical height increases, since
usually leaves a relatively flat slope below. This undermining g



IGURE 1.—*A*, A gully is gradually forming in this drainageway. If seeded down and left permanently in grass, the drainageway would carry run-off from the field without gullying. *B*, Sheep traveling up and down the slope made the paths that gradually developed into these gullies. Shifting or rearranging pasture lanes would have prevented this. *C*, Continued cultivation of this hillside will run gullies down the slope. Land as steep as this should be left in permanent cover.

n rapidly, particularly if the surface soil is underlain by sand or asily eroded subsoil.

In this manner gullies often start in the bank of natural watercourses hat have been eroded to a great depth. They extend back into the rainage area and grow deeper up the slope, often attaining depths f 50 to 60 feet or more. As they extend backward and cross lateral rainageways or natural depressions, waterfalls are in turn formed in he sides of these depressions, and branch gullies develop. This ranching may continue until a network of gullies covers the entire

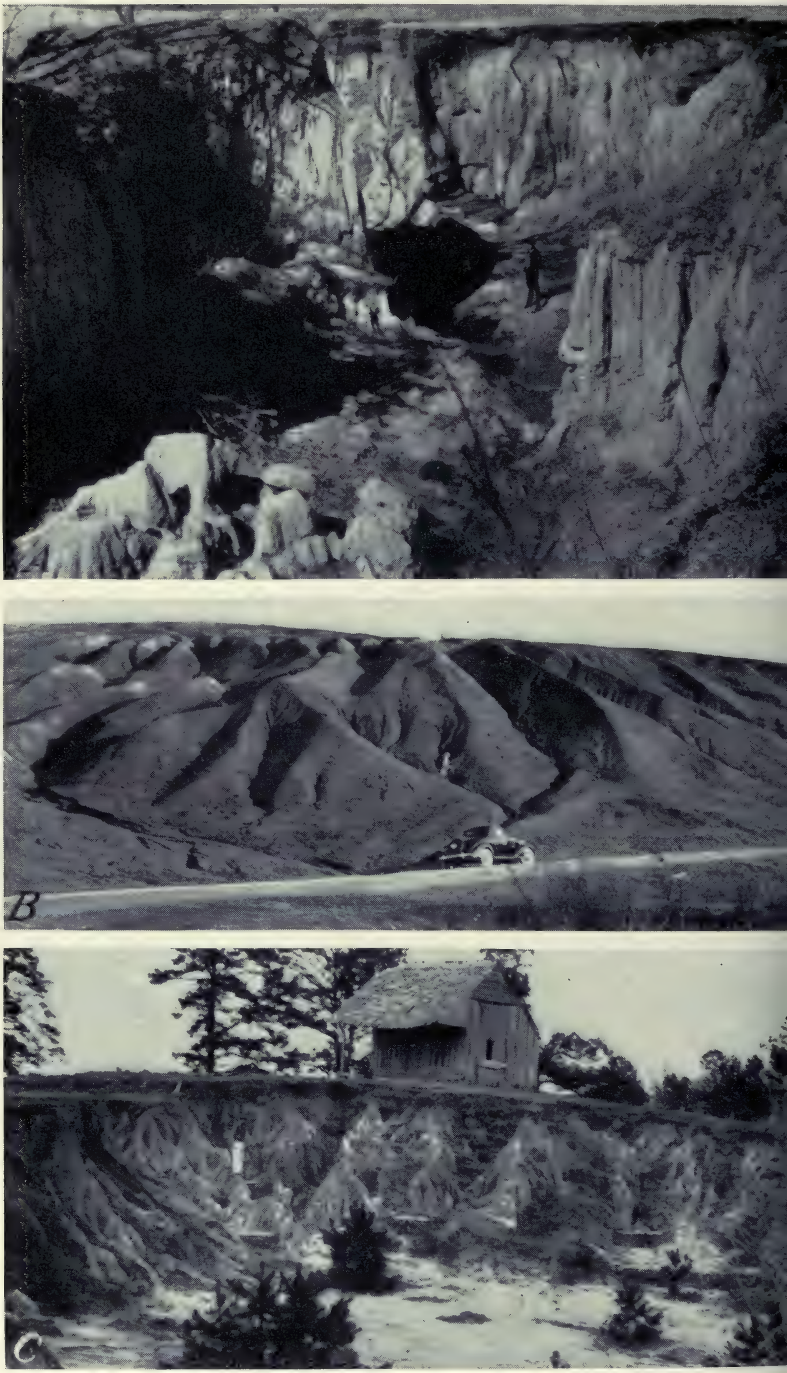


FIGURE 2.—*A*, Typical waterfall erosion. The U-shaped cross section is ch
acteristic of gullies formed by waterfall erosion. *B*, V-gullies, in which
major method of formation has been channel erosion. *C*, Alternate freez
and thawing helped to make this gully.

rainage area. Their growth is dependent mainly on soil character-tics, depth of overfall, and the size of the contributing drainage area ther than on the slope of the land. They may extend very rapidly ven through almost level land. They frequently grow at a rate of) to 50 feet a year, depending on the amount of run-off and the haracter of the soil. Some of them have been known to advance veral hundred feet during a single heavy rain.

In the Pacific Southwest some of the larger gullies formed in this ay are known as barrancas; in the Northwest they are called coulees; the Colorado Basin they are commonly referred to as arroyos or ashes.

CHANNEL EROSION

Channel, or ditch, erosion is essentially a scouring away of the soil y concentrated run-off as it flows over unprotected depressions. ullies formed by channel erosion usually have sloping heads and des (fig. 2, *B*). In fact, these gullies are often referred to as V-gullies. s the scouring continues the gully becomes longer, deeper, and wider. -gullies often attain lengths of 1 mile or more and depths and widths 20 to 40 feet. The extension in length is usually much faster than e widening of the gully because a greater volume of run-off passes ver the gully head than over the sides. Usually the gully does not lvance beyond the divide of the drainage area, but it may continue widen and deepen for years. The rate at which the gully deepens very rapid on the upper part of the area, where the slopes are com-ratively steep, and generally it decreases in the lower reaches as e slope decreases. Silting, rather than erosion, may occur if the annel or ditch emerges into a wide, flat-bottom drainageway. The creased volume of water, however, may offset the effect of moderate anges in slope along the lower reaches.

Channel erosion and waterfall erosion are commonly found in the me gully. The extension of the vertical head is usually by waterfall osion; and the scouring of the sloping bottom and sides by channel osion extends the depth and width. Gullies frequently start by annel erosion, and as an overfall develops at the head of the gully, e gully continues to develop by waterfall erosion. Gullies formed y channel erosion alone are often a series of closely spaced, parallel, -shaped gullies in the upper reaches of drainage areas, where slopes e fairly steep and the contributing area small. Channel erosion is sually present in gullies caused by waterfall erosion, except those ewly formed.

EROSION BY ALTERNATE FREEZING AND THAWING

Erosion by alternate freezing and thawing is prevalent in parts of e South, where alternate freezing and thawing temperatures are mmon in the winter and precipitation is generally in the form of in. Alternate freezing and thawing loosens the soil, which sloughs f and is then carried away by heavy rains. This occurs on all slopes a gully bank (fig. 2, *C*), and particularly on southern exposures. ullies formed in this way may extend in all directions, as the direction growth is not determined by the slopes of a field. Gully erosion by ternate freezing and thawing usually supplements waterfall and annel erosion, particularly in the Southern States. It may continue r years as the only form of erosion in gullies that are near a drainage vide and have little or no contributing drainage area.

In certain localities, during or immediately following prolonged rai and especially following periods of alternate freezing and thawing, m movements of soil in the form of slides, earth flows, and slumps ta place on steep slopes. A considerable number of gullies have th beginning in these disturbed or galled areas, particularly where t displacement exposes highly erodible subsurface material. Th mass movements usually develop conditions that are conducive gullying.

PREVENTION OF GULLIES

This bulletin deals with the control of gullies that begin as a res of man's abuse of the land. We can prevent these gullies. prevent the formation of a gully is much better and easier than control it once it has formed. We can never prevent erosion entir

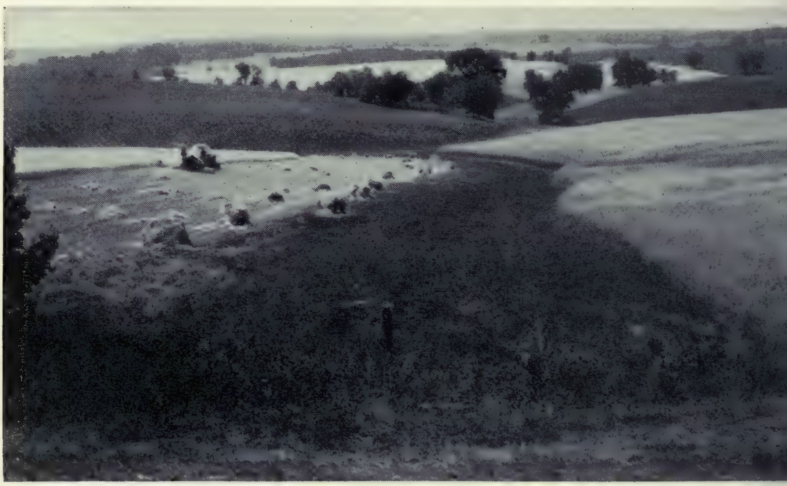


FIGURE 3.—A permanent meadow strip left as a drainageway. Even thou the slope is steep, this drainageway will carry run-off with little danger gullying.

because natural deterioration will continue as long as there is act by wind, water, or frost. But this natural geologic erosion is genera so gradual and moves at so slow a pace that it does no apprecia harm.

It is the erosion that arises from improper land use and metho of tillage that those who work the land can control. If a farm free of gullies (fig. 3) it will usually be found that the operator, und a well-developed land use program, uses good farming methods a is constantly on the alert against gullying. Wherever and whene he finds a danger spot he immediately takes steps to prevent t formation of a gully. It is easy to stop a gully when it has just beg to form, but if the gully is neglected for some time it can usually checked only with considerable work and at no little expense. should not be assumed, however, that just because no gullies visible on a field no erosion is taking place. There may be consid able sheet erosion, which is a forerunner of gullying unless it is checke

Constant vigilance is necessary to forestall gullying that starts om some practice that may seem of no consequence. The thoughtss driving of a wagon up or down a slope in a field made soft by in leaves a deep rut that may develop into a large gully unless it is some way filled in immediately. Filling the rut with straw or anure, or even spading it full, will usually prevent further damage.

Many farms have deep gullies because the feed lots were not proply located or because the stock trails cut deep into sloping pasture nes (fig. 1, *B*). Such gullies can usually be prevented by shifting nces as need arises and by rotating feed lots if gullies should begin form. Care should be used in the location and protection of ainageways, of watering places for livestock, and of roads or trails.

Unless caused by such minor things as drain outlets or stock trails, llying is usually preceded by sheet erosion. A close examination sheet erosion shows that the soil is not removed in strictly uniform eets or layers, as is so often supposed, but that numerous small vulets are formed, which might be classified as miniature gullies. hey are so small and close together that this process of soil removal usually spoken of as sheet erosion. When water from several of ese rivulets collects, larger depressions are formed, and they may ally become gullies. It thus is evident that where heavy sheet osion has been under way for a period of time, gullying is probably minent. Little sheet erosion occurs on a farm if its steep slopes e covered with trees and shrubs, its flat land and moderate slopes rmed according to approved cropping and tillage practices, and tervening areas reserved for permanent grasses (fig. 4).

The first step in preventing gullies is to plan or replan the farm so to get the best possible use of the land. This will include the tirement to permanent cover of such areas as are definitely too eep to farm; the utilization of the better agricultural land for culvated crops; the placing of moderately sloping and eroded areas meadow or pasture, if such areas cannot be economically tilled. ood land use may require that the general field pattern be considerbly changed and only the most suitable areas used for crops. In any instances fences will have to be reset and field roads rerouted get the best arrangements.

The best known methods of controlling erosion on those slopes at must be tilled are crop rotations, cover crops, strip cropping, d contour cultivation, alone or in combination with terracing here it is required. These practices are discussed in Farmers' ulletins 1776, Strip Cropping for Soil Conservation; 1758, Cover rops for Soil Conservation; and 1789, Terracing for Soil and Water onservation. Insofar as the methods of farming described in these ulletins control erosion they aid directly in preventing the formation gullies. The use of fertilizers and the conservative grazing of asture or range also protect the land from erosion.

One of the most important considerations in land use that prevents ullies is the proper disposal of excess run-off water from the fields. very farm has its own natural drainage pattern, which, in general, is difficult to change. This pattern includes all water-conveying epressions or channels of either continuous or intermittent flow. xcept for minor variations it should be followed in planning fields nd, especially, in locating outlets for terraces or diversion ditches.

Natural drainageways should be used, wherever possible, and th should be left in sod in order that they may continue to carry wat without gullying. The extra ground that may be cropped by farmi these drainageways can in no way compensate for the damage th will occur if severe gullying is begun by cultivating the drainagewa with the rest of the field.

If the general drainage pattern is not considered or followed planning for land use, either a very expensive artificial system dispose of surplus run-off will be required or the water must be co centrated in undesirable locations that will eventually gully. If natural drainage unit is not complete on one farm, but covers t or more farms, a better water-disposal plan can be worked out if t farms are considered collectively.

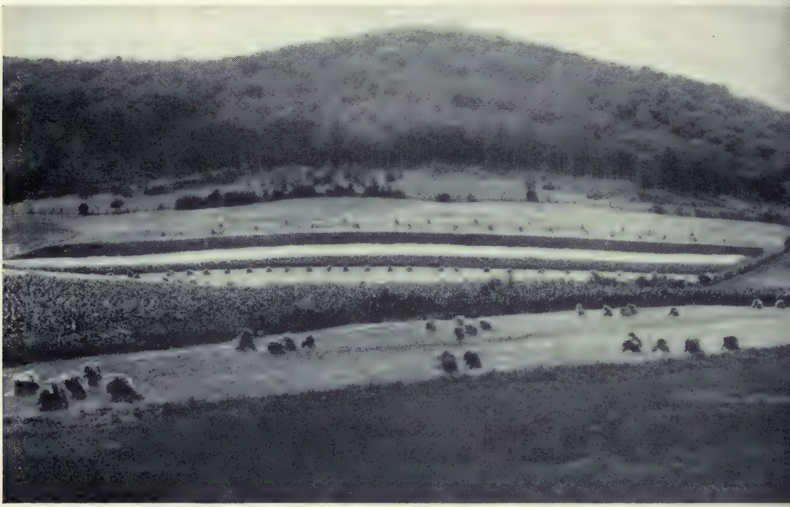


FIGURE 4.—Where there is proper land use there are few gullies. The steep up slopes have been left in woods, the lower slopes are in meadow or perman pasture, and the bottom land is strip-cropped.

If the results of careless cultural practices could have been forese or if just a little time had been spent in checking the beginning o small gully, many of the present large gullies would never have forme Once the gullies have formed and prevention is too late, it is s possible to stop serious erosion in the gullies and cover most of the with vegetation.

PLANNING GULLY CONTROL

LAND USE AND CONTROL COSTS

The size of both the gully and its drainage area are of great imp tance in planning the control of gullies. In order to avoid confusi as to what will be considered large or small gullies, it seems desira to classify them. The differences of opinion as to size groupings mak such classification difficult. A large gully in the northeastern part the United States may be considered a medium-sized gully in t Southeast. The following classification of gullies according to si is suggested for general use. The range of these groupings is necessar ide in order to accommodate the wide variations in field conditions.

Small gully: Less than 3 feet deep.
Medium-sized gully: Three to 15 feet deep.
Large gully: Over 15 feet deep.

It is recommended that gullies be further classified according to the ize of their drainage area. A small drainage area is 5 acres or less; medium-sized drainage area, 5 to 50 acres; and a large drainage rea, over 50 acres. According to this classification a small gully with medium-sized drainage area is a gully less than 3 feet in depth with a atershed of 5 to 50 acres.

If a gully directly menaces a building or a highway structure it is a ather simple matter to determine how much money may be spent to rotect this property as its value is usually known or can be readily stimated. Estimating the damage of gullying in a field or the ustifiable expenditure for checking it is not so easy, as it is much ore difficult to determine the true value of the land and the exact xtent of present and ultimate damage.

"How much am I justified in spending?" This is the first question very farmer asks himself when he plans to stop gullying on his land. f a gully has already advanced within a short distance of its drainage ivide it may be unwise to spend very much in controlling the gully ecause it can do only a little more damage. After a gully has eaten ts way to the head of the watershed it usually ceases to be active, and f it is protected from livestock, natural revegetation will reclaim it ver a period of time. If a gully has advanced only a short distance nto the watershed there is more justification for establishing immeiate control (fig. 5).

The actual acreage of the land surface destroyed by a gully may be elatively small, but this gully may so dissect a field or threaten djacent areas as to hamper or endanger farming operations on the ntire watershed, either immediately or in the future. And just one adly gullied field on a farm creates an unsightly appearance that educes the value of the entire farm. The value of a farm on which ullying is active may therefore decrease much more rapidly than the resent state of gullying would indicate.

Although severely gullied land has little immediate value some conrol measures are usually warranted on all such areas if only to protect djacent lands. But it is well to determine what is the most economial and suitable protection for each gullied area. The cost of conrolling a gully and the type of protection should always be considered n relation to the use that can be made of the gullied land as well as the rotection to adjacent areas that such control will afford.

For example, a badly gullied field that could not be restored to sefulness as cropland except at too great expense may be retired to oodland, for which purpose it may have considerable value. If this s done, little expenditure for gully control need be made because a rotected plantation over the larger part of the drainage area will rdinarily prevent further gullying.

Less seriously damaged areas may be used for permanent pasture r meadow, provided a suitable cover can be established and the cost f controlling the gullies can be kept commensurate with the returns o be expected from the land. Land that is to go into permanent pasture or meadow often requires considerable treatment to provide a satisfactory grass cover and to facilitate future farming operations.

More expensive gully treatment is usually required on gullied land to be retained for crops, but the fertility or value of the land may justify it. In general, however, it may be said that complete, immediate reclamation of gullies is too costly unless the gullies are still so shallow that they can be crossed with machinery or terraces. The expense of installing the control measures necessary to check gullies on highly erodible areas to be kept in cultivation is frequently considerable. On these areas it is usually more economical to check active erosion within the larger gullies and then reclaim the gullies over a period of years through the use of vegetation.

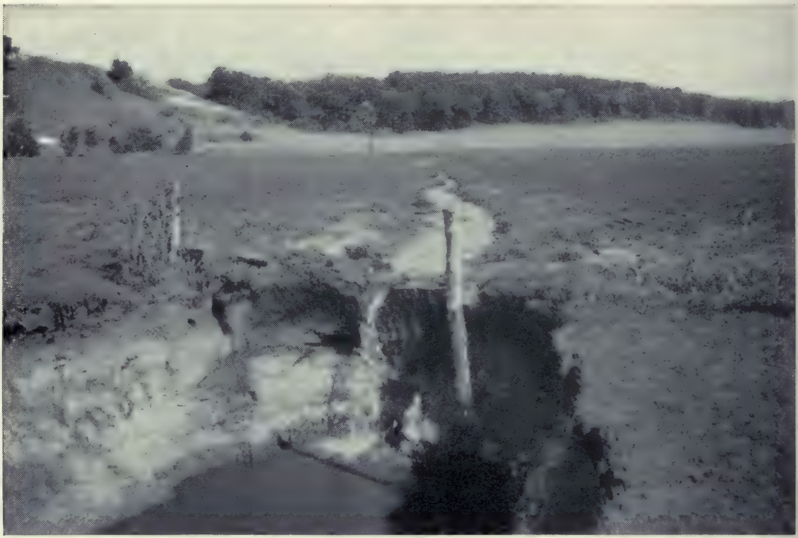


FIGURE 5.—This gully head is just beginning to eat its way across a cultivated field. It can still be controlled with relatively low cost. If allowed to erode unchecked, it will advance across the entire field. A gully has no respect for fence lines as is evidenced by the fence post dangling in mid-air. Note the steep banks along the gully head. This is an excellent example of waterfall erosion.

There is a special type of treatment in gully control that is peculiar to the arid and semiarid parts of the United States. It has been used on large barrancas and arroyos in locations where land values are high or where it has been found necessary to protect reservoirs and irrigation systems from excessive silting. For example, where a large gully is biting into valuable orchard land it may be justifiable to fill the gully completely through the use of one or more silt-retention dams. These dams can also be used if silt deposits are being carried into irrigation systems by an actively cutting gully, even though the gully head may be under control. The silt load can be materially reduced by placing large multiple-lift, overpour dams in the alluvial-fill valleys. These structures are located at sites where the grade of both the gully and valley floor is mild and where the valley floor is sufficiently broad to permit the spreading of water. When properly located, these dams serve to stabilize active lateral cutting and they will gradually rebuild the gully by collecting silt. They often serve the twofold purpose of holding back silt and providing water for supplemental irrigation.

TREATMENT OF GULLIED DRAINAGE AREAS

Complete gully control includes proper treatment of the drainage area as well as of the gully itself. If the control treatment is applied only to the gully, it is likely that all control efforts are being directed at the results and the cause neglected. Neglecting the drainage area usually makes it much more difficult, if not impractical, to control a gully satisfactorily and often leads to the formation of new gullies faster than the older ones can be checked. For example, if an eroding field is terraced and nothing further is done to control erosion on adjacent fields it is likely that gullies will gradually encroach upon the terraced field and damage it.

If a drainage area is gullied, it will require more complete treatment than if the gullies were not present. For example, regular cropping and tillage practices that conserve the soil may permit the safe production of farm crops on an ungullied drainage area, but if gullies are present it may be necessary to put a permanent cover of vegetation on the area. Or a relatively flat, ungullied drainage area may be cropped without excessive soil and water losses if only crop rotations, contour tillage, and strip cropping are practiced, whereas the presence of a few gullies on that area would make it necessary to use terraces in addition to these other conservation practices if the same crops were to be produced without excessive soil loss and further gullying checked.

The plan of treatment for gully control, in order to be complete, should thus include treatment of the drainage area based on good land use and soil- and water-conserving practices such as strip cropping, contour tillage, crop rotations, and cover crops. These should be combined with terracing or contour furrowing where applicable. Only in this way is it possible to achieve a measure of success in the control of gullies or any assurance that such control will be more than short-lived.

ESTIMATING RUN-OFF

A soil can absorb rainfall up to a certain rate. When this rate is exceeded some of the water begins to run off. That is why heavy and rapid downpours are much more likely to cause harmful erosion than equivalent amounts of rain that fall over longer periods. This fact is so generally understood that special terms have come into use to express this relation. For example, a slow, steady rain is ordinarily called a "ground soaker," and a dashing downpour is commonly referred to as a "gully washer." The more rapid the rate of rainfall, other conditions being the same, the greater the proportion of rain lost as surface run-off.

It is the run-off that loosens the soil and carries it away. Without run-off there would be no gully erosion. Furthermore, the degree of gullying is directly associated with the rate of run-off. A high rate is usually more destructive than a low rate. The rate of run-off is generally a more accurate indication of the probable damage that run-off will cause than the amount of run-off. The rate of run-off is dependent on the size, shape, and slope of the drainage area; the extent, nature, and condition of the soil and cover; the intensity and duration of the rainfall; and the slope and condition of the drainage channels. High rainfall intensities of long duration, poor plant cover, saturated, frozen, or impervious soils, and steep slopes all contribute to high run-off rates.

One must estimate the probable rate and amount of run-off from a

TABLE 1.—*Run-off from drainage areas*[1] *of 1 to 300 acres, based on a 10-year rainfall intensity-frequency*

Watershed characteristics[2]	Group[3]	Run-off from drainage areas of—																						
		1 acre	2 acres	3 acres	4 acres	5 acres	10 acres	15 acres	20 acres	25 acres	30 acres	35 acres	40 acres	45 acres	50 acres	60 acres	70 acres	80 acres	90 acres	100 acres	150 acres	200 acres	250 acres	300 acres
		Cubic feet per second	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*
Rolling timber	1	2	4	5	6	8	16	23	29	35	39	44	49	55	62	73	83	90	97	103	145	185	216	245
	2	2	3	4	6	8	15	21	26	32	35	40	45	50	56	65	74	80	86	91	127	160	186	210
	3	2	3	4	5	7	13	19	23	28	31	35	39	43	48	56	63	68	73	77	105	130	150	168
Hilly timber	1	3	5	6	8	9	18	27	33	40	45	52	57	64	71	85	96	104	114	122	165	213	252	285
	2	3	4	6.	8	9	17	25	31	36	41	47	52	58	64	75	85	92	102	108	145	184	217	244
	3	3	4	5	7.	8	15	22	27	32	36	41	45	50	55	65	73	79	86	91	120	150	175	195
Rolling pasture	1	5	8	12	15	18	33	47	58	67	77	87	99	110	121	143	164	181	197	208	290	369	433	489
	2	4	8	11	14	17	30	43	53	61	70	79	90	99	109	128	146	160	175	185	254	319	371	419
	3	4	7	10	13	15	27	38	47	54	61	69	78	86	94	110	125	137	148	155	210	260	300	335
Hilly pasture	1	7	13	16	20	24	40	55	67	79	91	102	114	128	142	166	190	210	227	241	334	426	497	572
	2	7	12	15	19	22	37	51	61	72	82	93	104	116	128	148	169	186	202	214	294	369	428	490
	3	6	11	14	17	20	33	45	54	63	72	81	90	100	110	128	145	159	171	180	242	300	345	392
Rolling cultivated	1	8	15	23	29	34	57	77	95	111	128	145	162	182	201	238	271	299	324	344	476	605	720	822
	2	8	14	22	27	32	53	71	87	101	116	132	147	164	181	212	242	265	288	306	419	522	620	703
	3	7	13	20	25	29	47	63	77	89	102	115	128	142	156	183	207	226	244	257	345	425	500	562
Hilly cultivated	1	10	17	27	35	42	70	94	114	134	154	174	193	219	241	285	323	358	389	416	580	727	863	986
	2	10	16	25	33	40	64	86	104	124	139	158	177	198	217	254	288	317	345	369	509	630	742	843
	3	9	15	23	30	36	57	76	92	107	122	138	154	171	187	219	246	271	292	310	420	512	600	675
Terraced rolling cultivated	1	6	9	14	18	21	40	54	68	81	93	107	120	137	155	189	223	264	293	315	465	605	720	831
	2	5	9	13	16	20	36	50	62	73	84	97	109	124	139	168	199	234	260	280	409	522	620	712
	3	5	8	12	15	18	33	44	55	65	74	85	95	107	120	145	170	200	220	235	337	425	500	570

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[1] Based on the recommendations of C. E. Ramser.

[2] "Rolling" designates 5- to 10-percent slopes; "hilly," 10- to 30-percent slopes.

[3] Group 1 includes the entire States of Florida and Louisiana, the southern portions of Georgia and Alabama, the southern half of Mississippi, and the southeastern part of Texas. Group 2 includes central Texas, all of Oklahoma except the Panhandle, the eastern half of Kansas, southeastern Nebraska, the southern half of Iowa, western Illinois, all but the southeastern tip of Missouri, all but the northeastern corner of Arkansas, South Carolina, that part of Mississippi, Alabama, and Georgia not included in group 1 (except for the extreme northern parts of these States), the eastern and central portions of North Carolina and Virginia, Delaware, the eastern half of Maryland, New Jersey, and the southern extremes of Connecticut and Rhode Island. Group 3 may be used for all other areas except where local information indicates higher run-off rates.

articular drainage area before it is possible to design structures to ontrol the run-off or even to know what structures can best be used. un-off rates are generally of more significance than the total amounts f run-off discharged in computing required discharge capacities for ontrol structures. A possible exception would be where control is btained through run-off retention or absorption, in which case the mount of run-off may become the deciding factor rather than the aximum rates. Terraces, diversion ditches, drainageways, and pillways must have sufficient capacity to carry the run-off resulting om the maximum rainfall intensities likely to occur during the prob- ble life of the control structure. This period is generally from 5 to 0 years for small check dams, terraces, and diversion ditches and om 20 to 50 years for the more expensive soil-saving dams. The aximum rainfall intensity that is likely to occur during a period of years is usually spoken of as having a frequency of 5 years, and milarly for any other number of years. For example, a dam de- gned with sufficient spillway capacity to handle the run-off resulting om a rainfall intensity that the records show will probably occur nly once in 10 years is said to be designed on a 10-year rainfall tensity-frequency.

It is evident that considerable experience is required to estimate un-off from a drainage area. An inexperienced man is apt to be onsiderably in error in his estimates. Table 1 is included for the onvenience and use of those inexperienced in making run-off deter- inations. Unless an individual is entirely familiar with the procedure f estimating run-off rates it is suggested that he use this table in rriving at run-off values for gully-control structures. Its use will sure reasonably safe design values for even the more adverse condi- ons that may be encountered in the field. The run-off rates given table 1 should not be used for the design of large or expensive ermanent dams, which are usually designed for a rainfall intensity- equency exceeding 10 years.

Suppose it is desired to know the probable run-off from a rolling ltivated field comprising about 35 acres, located in southern Iowa. table 1 find "rolling cultivated." Southern Iowa is in group 2, so llow the line from the "2" opposite "rolling cultivated" across the age to the column headed 35 acres. The figure here is 132. It dicates that the probable rate of run-off on a 10-year frequency from is 35-acre drainage area will be about 132 cubic feet per second. It important that the drainage areas be properly classified according location in group 1, 2, or 3, as it can be seen that there is consider- ble variation in the run-off rates in each of these groups.

It frequently occurs that a drainage area is a composite of pasture, oods, and cultivated land. In order to arrive at the run-off from ch an area, the run-off from the several units should be estimated in is way. Suppose a drainage area (located in group 2) consists of 0 acres of land with slopes of between 10 and 30 percent, which is assified as "hilly," 30 acres, or one-half of this drainage area, is in mber, and the remainder is in pasture. From table 1 the run-off om 60 acres of hilly timber is found to be 75 cubic feet per second, ne-half of which would be 37½ cubic feet per second. The run-off rom 60 acres of hilly pasture would be 148 cubic feet per second, ne-half of which would be 74 cubic feet per second. Adding these, he total probable run-off is found to be 111½ cubic feet per second.

It is important to note that the proper figure is computed in th manner and not by adding the run-off from a 30-acre watershed timber and a 30-acre watershed of pasture.

CONTROLLING RUN-OFF

Applicable methods of handling the run-off to facilitate gully co trol differ for various types and sizes of gullies and drainage area Other important factors that in part determine the best method be used are soil types and climatic conditions. From the standpoi of economy and practicability, the methods should be considered the following order:

1. Retention of run-off on the drainage area.
2. Diversion of run-off above the gullied area.
3. Conveyance of the run-off through the gully.

In field practice, local conditions often prohibit the use of certa of these methods, but they should always be given consideration in t order named. No method should be discarded as impractical un thorough investigation has proved it to be so. Frequently the mo practical solution will be the use of a combination of the three method It should be kept in mind that, wherever practical, vegetation shou be reestablished in gullied areas. The methods of controlling run- are to aid in such establishment and are not to be considered as su stitutes that will make unnecessary the use of vegetation on eith the drainage area or in the gully.

Whatever the method of run-off control used, it should be careful planned and executed. Haphazard work will lead to disappointme and may actually aggravate rather than alleviate the conditions bei treated. Any work that is done should further the general plan f control of the gullied area.

RETENTION OF RUN-OFF

Keeping the soil and moisture on a gullied field by means of prop land use and approved cropping and tillage practices lessens co siderably the amount of run-off to be carried away through the gul and thereby reduces the amount of treatment needed in the gul itself. If these practices still permit so much run-off to enter t gully that vegetation cannot be established there, the use of subso ing, contour furrows or ridges, listing, level terraces with closed end or earth fills to impound water may also be advisable. These erosi controls are not difficult to construct, and they retain considerab moisture for crops. If they can be applied over the entire draina area of small gullies or even of medium-sized gullies that have sma to medium-sized drainage areas on which the soils are absorpti the slopes moderate, and rainfall low, little or no control may necessary in the gully itself.

SUBSOILING

On areas having absorptive soils, subsoiling small watersheds abo gullies to a depth of 1 to 2 feet has proved effective in reducing t run-off sufficiently to permit satisfactory establishment of a vegetati cover in the gully. Subsoiling requires the use of a special subsoili machine. Machines of various widths may be used, depending e power available. The chisel points are usually spaced on 1- to oot centers, depending on the depth of penetration desired. Subling should be done on the contour and may be either in strips or ntinuous on the field, depending on the amount of absorption quired. It is frequently used in conjunction with contour ridges absorptive-type terraces. A small subsoiled strip immediately ove contour ridges or terraces will open up the soil so that much re run-off can be absorbed.

CONTOUR FURROWS AND LISTING

Contour furrows or ridges are primarily small ditches or ridges nstructed across the slope with a plow, lister, or terracing machine . 6). Their storage capacity is dependent on their water cross-

URE 6.—There will be little run-away water from this contour-furrowed field to give gullies a start. The stock pond also retains considerable water.

tional area and their spacing. Various storage capacities can be tained by regulating the size and spacing of the furrows.

The storage capacity for contour furrows or ridges with various acings and water cross-sectional areas is given in table 2. If, for ample, it is desired to store 2.5 inches of run-off in contour furrows ving a water cross section of 1.25 square feet, the furrows should spaced about 6 feet apart. The storage capacity of the furrows en in table 2 does not include the water that seeps into the soil. e ends of the furrows or ridges are usually turned uphill and the annels blocked at occasional intervals so that, in the event of a eak, all the water cannot drain from the furrow and thus encourage llying. Lister furrows (fig. 7) have been used extensively on ltivated land in the Great Plains to keep rainfall on the fields. gullied watersheds they can be used to keep water out of the llies.

TABLE 2.—*Horizontal spacing of contour furrows or ridges*

Storage capacity (inches of run-off)	Distance between furrows where the water cross-sectional area [1] is—															
	0.50 square foot	1 square foot	1.50 square feet	2 square feet	2.50 square feet	3 square feet	3.50 square feet	4 square feet	4.50 square feet	5 square feet	5.50 square feet	6 square feet	6.50 square feet	7 square feet	7.50 square feet	8 square feet
	Feet	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
0.25	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0	312.0	336.0	360.0	384.0
0.50	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0	132.0	144.0	156.0	168.0	180.0	192.0
0.75	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0	128.0
1	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0	90.0	96.0
1.25	4.8	9.6	14.4	19.2	24.0	28.8	33.6	38.4	43.2	48.0	52.8	57.6	62.4	67.2	72.0	76.8
1.50	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0	64.0
1.75	3.4	6.9	10.3	13.7	17.1	20.6	24.0	27.4	30.9	34.3	37.7	41.1	44.6	48.0	51.4	54.9
2	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0	48.0
2.25	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.0	34.7	37.3	40.0	42.7
2.50	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6	36.0	38.4
2.75	2.2	4.4	6.5	8.7	10.9	13.1	15.3	17.4	19.6	21.8	24.0	26.2	28.3	30.5	32.7	34.9
3	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0	32.0
3.50	1.7	3.4	5.1	6.9	8.6	10.3	12.0	13.7	15.4	17.1	18.0	18.9	19.7	20.6	21.4	22.3
4	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0
4.50	1.3	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3	14.7	16.0	17.3	18.7	20.0	21.3
5	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	13.2	14.4	15.6	16.8	18.0	19.2
5.50	1.1	2.2	3.3	4.4	5.5	6.6	7.6	8.7	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.5
6	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
6.50	.9	1.8	2.8	3.7	4.6	5.5	6.5	7.4	8.3	9.2	10.1	11.1	12.0	12.9	13.8	14.8
7	.9	1.7	2.6	3.4	4.3	5.1	6.0	6.9	7.7	8.6	9.4	10.3	11.1	12.0	12.9	13.7

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[1] For water cross-sectional areas in excess of 8 square feet the required spacings can readily be determined by multiplication. Example: For a water cross-sectional area of 15 square feet the spacing would be 3 times that required for a cross section of 5 square feet; it would be about 90 feet if 2 inches of run-off is to be retained.

GURE 7.—These lister furrows are holding water on the field. Keeping excess
water out of gullies makes it much easier to get vegetation started in them.

ABSORPTIVE-TYPE TERRACES

Absorptive-type terraces are constructed larger than contour ridges,
d they provide more storage capacity, are spaced farther apart, and
n be farmed over if necessary. Their ends can be left partly or com-
etely open, depending on the necessity for some drainage as a factor
safety against overtopping. Where these terraces are to be de-
nded upon to retain all of the excess rainfall, they should be used on
ly moderate land slopes (generally less than 2 percent) and pervious
l types. It will usually be necessary to provide storage for at
st 2 to 4 inches of run-off in areas of low rainfall, and a capacity of as
ch as 6 to 7 inches may be necessary in areas with high rainfall. The
pense and difficulty of providing a storage capacity of 6 to 7 inches usu-
y makes the use of adequate retention measures impractical in areas
ere rainfall is high. Furthermore, if crops are to be grown on a field
ntaining these terraces, the retention of an excessive amount of wa-
may damage the crops before the water can be absorbed by the soil.

EARTH FILLS

On cultivated areas with absorptive soils, small- or medium-sized
llies with small watersheds can sometimes be reclaimed by placing
series of earth fills across the gullies. Their spacing is dependent
the slope of the gullies. The use of this method is limited to
eas where sufficient storage capacity can be provided above the
rth fills to retain the major portion of the run-off that is commonly
scharged from the drainage area. The earth fills are extended above
e ground level, and short diversion ditches or spur terraces are
metimes used to lead overflow away from the ends of the fills in
der to prevent damage by erosion. Where a series of earth fills
used and the overflow is diverted from alternate sides, somewhat
a sirup-pan retention is effected. The diverted water is finally
her impounded in the gully or absorbed by the soil. The use of
is or similar methods requires considerable attention. As the
rage capacity of the small reservoirs is gradually reduced by silt

deposition, the amount of overflow will increase and may start erosi unless sufficient plant cover has become established to afford protectio

On fields where the measures discussed in this section do not pr vide sufficient storage capacity to retain the run-off and keep it o of the gullies, drainage-type terraces or diversion ditches may al have to be used to divert part of the run-off.

DIVERSION OF RUN-OFF

Where necessary and practical, run-off should be diverted from gully head before control measures are attempted within the gul This principle generally applies to gullies of all sizes except tho having so small a drainage area that the run-off is negligible, as f example, a gully with a drainage area of less than an acre. In usi either terraces or diversion ditches careful consideration should given to the disposal of the diverted water. If safe disposal cannot provided, the water should not be diverted. The disposal of conce trated run-off over unprotected areas may cause gullying.

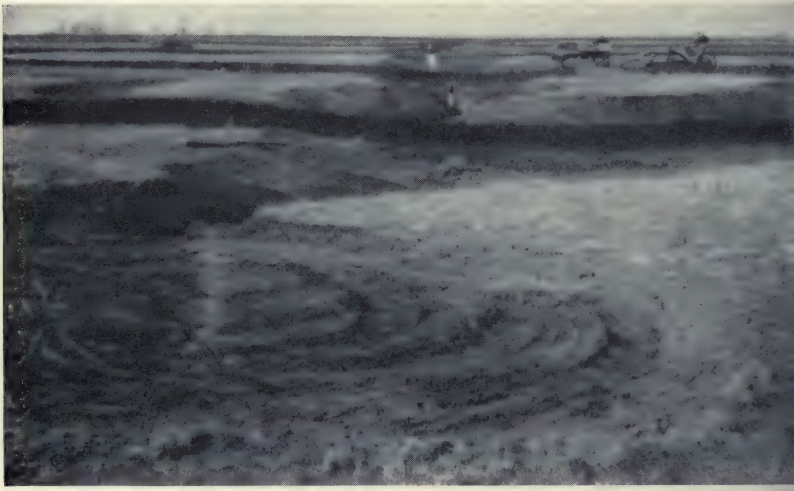


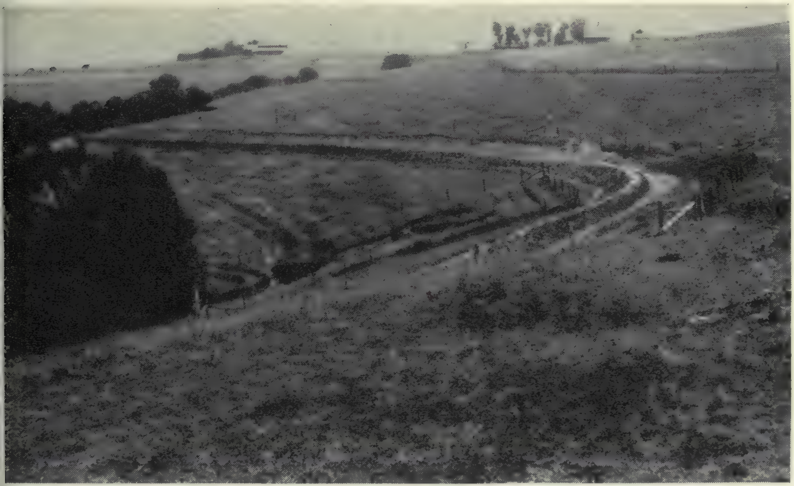
FIGURE 8.—The terraces on this field run across the gully, intercepting the fl of water down the gully. The fills across the gully must be carefully made that the terraces will prevent further gullying and reclaim the gullied area.

Terraces are very effective in the control of small gullies on cul vated fields or even medium-sized gullies that are not too deep to crossed with the terracers (fig. 8). Terraces placed above a gul too deep to be terraced across will divert headwaters from the gul which may then be treated further if necessary. Terrace constructi may be difficult and somewhat expensive on gullied areas, but despi this it is frequently the most satisfactory control measure for terrac able slopes, and particularly where numerous parallel gullies are e countered on slopes that are difficult to vegetate. Figure 9 shows previously gullied field that has been almost completely reclaimed l terracing. The terraces were constructed across the gullies. Th diverted the run-off at points where the terraces crossed the gullies ar allowed the gullies gradually to fill with silt.

If the slopes above a gully are too steep to terrace or if the draina ea is pasture or woodland, diversion ditches (fig. 10) may be used keep run-off out of the gully. Diversion ditches are particularly apted to areas already covered with trees or grass because ditches low these areas are not so likely to receive silt loads from the drain-

URE 9.—Before this field was terraced and contour-tilled it was gullying extensively. The scars of some of these gullies are still visible in the immediate background.

e area. Diversion ditches are not recommended immediately be- v cultivated fields not fully protected from sheet erosion unless a rmanent filter strip of close-growing vegetation is placed above the ch to catch the silt carried in the run-off from the fields. This filter ip should have a minimum width of 50 feet and adequate cover to



URE 10.—The water is intercepted by a diversion ditch above the gully and carried to a disposal point so slowly that little erosion occurs. The fence keeps out livestock.

er out and retain the silt in the run-off. This will reduce silt deposi- n in the ditch channel and eliminate the need for much subsequent intenance.

Diversion ditches should be made large enough to carry all the run- that will be discharged from the contributing drainage area during

periods of maximum run-off from rains within the design frequen
selected (p. 13). This run-off should be conveyed through the dit
at nonerosive velocities. The velocity of run-off in the ditch can
controlled by regulating the grade and shape of the water chann
Wide, shallow ditches on mild grades produce lower velocities th
narrow, deep ditches on steep grades. In channels maintained by
permanent plant cover a higher discharge velocity is recommend
than in raw channels. The higher velocity is essential to preve
undue silting.

For shallow earth channels not having a cover of vegetation t
maximum grade should seldom exceed 12 inches per hundred fe
of length in order to prevent scouring velocities. Where a permane
plant cover is to be maintained in the channel, grades as high
2 to 3 percent or more may be used. Serious scouring will likely occ
with these steeper grades if the vegetative protection is ever d
stroyed, and they should be used only where adequate vegetative pr
tection can be depended on during all periods that produce run-off.

The terrace-type diversion ditch is extensively used for ordina
locations where the watershed area is about 7 or 8 acres (fig. 1
This type of diversion dit
is constructed from both t
upper and lower sides on r
atively flat slopes. On stee
er slopes (of above 3 or
percent) construction is ge
erally from the upper si
only. There are, of cour
many variations from t
indicated cross sections b
cause of the local variatio
in soil types, available co
struction equipment, rai
fall, and slopes. The dit
should be constructed a
cording to the required c
pacity. The settled depth
the water channel should s
dom be less than 18 inche
and a minimum water cros
sectional area of 7.5 squa
feet is suggested for draina
areas up to 5 or 6 acr
Drainage areas up to 10 acr
require a channel depth of
inches and a minimum cro
section of 12 square feet.

For larger drainage are
cross section *C*, shown in fi
ure 11, is suggested, esp
cially on the steeper slop
It is recommended that t
services of an individual wi
experience in hydraulic d
sign be secured to compu

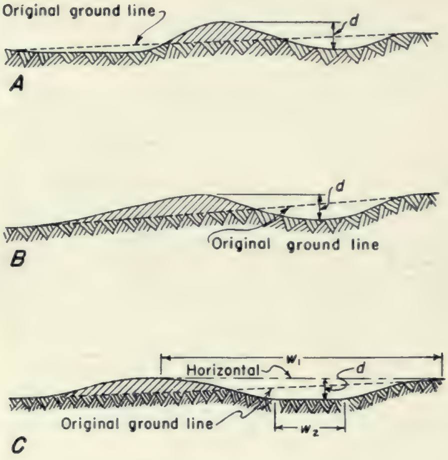


FIGURE 11.—Diversion-ditch cross sections: *A*, Terrace-type diversion ditch on relatively flat slopes. Construction from both sides. Minimum value of *d* about 18 inches. *B*, Terrace-type diversion ditch on steeper slopes. Construction generally from the upper side only. Minimum value of *d* about 18 inches. *C*, This type of diversion ditch is suggested for drainage areas exceeding 10 acres, especially on the steeper slopes. *d* should be a minimum of 22 inches. Side slopes should be at least 4:1 where land slopes permit. The approximate water cross-sectional area of the ditch is $\frac{(w_1+w_2)}{2}d$.

hannel capacities and dimensions for these larger watersheds. A oorly designed diversion ditch is more apt to induce than to prevent ullying.

The diversion ditch should be set back from the head of the gully minimum distance of three times the height of the gully overfall. ow points in the ridge and high points in the channel should be orrected before the ditch is put to use. If well-protected natural utlet locations can be found, no special outlet revegetation or contruction will be necessary. If none are available it is necessary to ke certain precautions to spread the concentrated run-off on vegeted areas. Natural outlets should always have preference if they re satisfactory. It is sometimes possible to discharge the diversion itch into an outlet or drainageway already established for a terrace ystem. If this is done, provision should be made for the additional ater to be carried by the outlet channel.

Sometimes it is necessary to establish sodded outlet areas before onstructing the diversion ditch. Contour furrows have also been sed to spread and absorb water from diversion ditches where soils re pervious and the amount of run-off is not very large. The furrows hould preferably be established at least a year before the water is iverted into them, so that the furrows as well as the intervening reas may become vegetated before additional run-off is discharged nto them.

CONVEYING RUN-OFF THROUGH GULLIES

If it is not possible to keep water out of gullies by retaining it all on e watershed or diverting it from the gullies, the run-off must be onveyed through the gullies. To do this and to check erosion in ose gullies at the same time is possible if vegetation can be estabshed in the gullies or mechanical structures built at critical points supplement vegetation or to give complete control.

It is emphasized, however, that where a gully is located in a natural rainageway that is to form part of the disposal system for surface n-off, it becomes necessary to convey run-off through the gully. ny erosion control applied in the gully must not reduce the caacity of the drainageway below that required to carry the run-off ischarged into it.

It is usually much more difficult to establish adequate vegetation a gully through which run-off must be conveyed during the period f establishment than in one from which run-off can be diverted. rodible portions of a gully through which water is conducted must sually be protected by transplanting sod, by the use of specially chored mulches, or by the use of mechanical structures. The meanical structures need be only temporary if the plant cover, once stablished, can provide sufficient protection.

If mechanical measures will ultimately be required for satisfactory ontrol, permanent structures, such as masonry check dams, flumes, r earth dams, supplemented by vegetation, should be provided to onvey the run-off over critical portions of the gully. Detailed inforation on the use of vegetation and mechanical structures in gullies given in the following sections of this bulletin.

VEGETATION

The methods of preventing gullies that have been recommended, s well as the control measures described on pages 28 to 57, are for the purpose of reducing or controlling run-off so as to make easier to establish vegetation. The objective of gully control is, fact, the establishment of an erosion-resistant cover of plants th not only stabilize the gullies but also produce a usable crop, a hence a supplementary income. Just what kind of plants are to

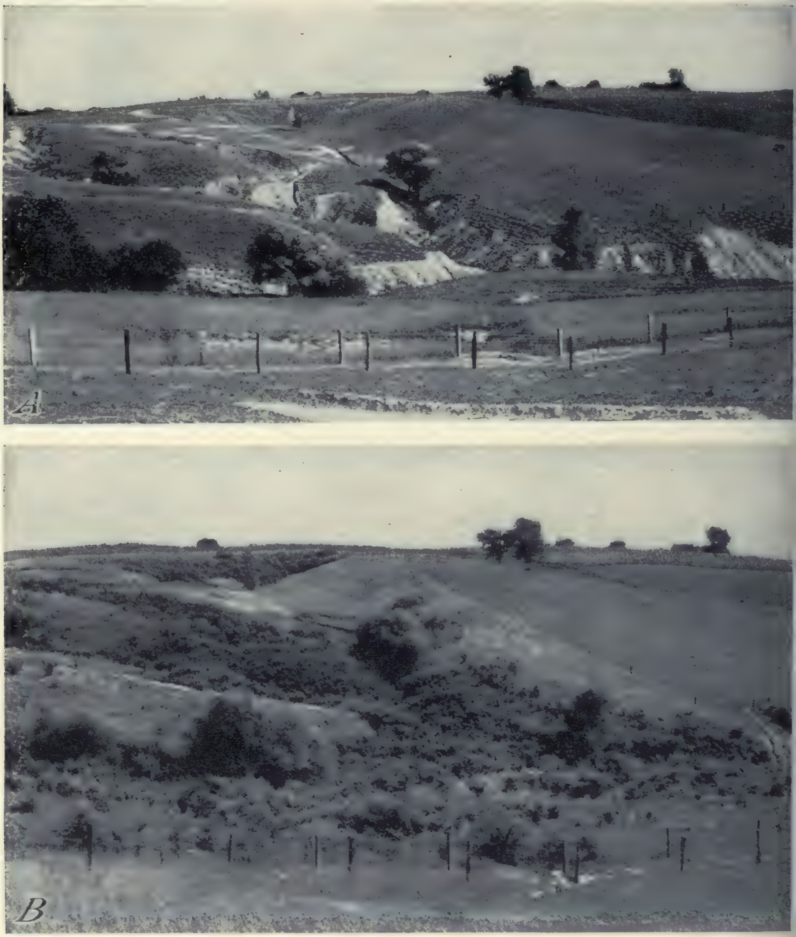


FIGURE 12.—*A*, This picture was taken soon after the gullied area had be fenced and planted to black locust trees. Very little bank sloping was do preparatory to planting. *B*, The same area 2 years later. The raw gu banks have been almost completely covered with vegetation.

used and how they are planted will, of course, vary according locality.

In any part of the country, gullied areas are usually the mo difficult places on which to try to grow plants. The topsoil is gon the subsoil is poor or is gone; and the layers finally exposed in t gully may be hardpan or even rock. The revegetation of such plac will be difficult. Yet, if the run-off water can be diverted from i old path through the gully, if the soil is given a little preparatio nd if the area is temporarily protected from trampling by livestock, plant cover can be established (fig. 12).

Bank sloping is expensive as a means of preparing a gullied site for lanting. It can usually be justified only if the banks of the gully re so steep that vegetation cannot otherwise be established or if it desired to partly fill a small gully to facilitate tillage operations. s little bank sloping as possible should be done, for under ordinary onditions the banks will gradually assume a stable slope. The ecessary sloping can be done by hand labor, by machinery, or by lasting.

Sloping by hand labor is slow and may be expensive if much of is to be done. A more practical method is to use a light walking low and team. Considerable skill is necessary to maneuver the plow nd team properly, but with a little practice it is soon possible to plow down" a gully bank. For the first few rounds it may be ecessary to hitch a chain to the plow if it is difficult to bring the eam near the edge of the gully bank. Fine brush, straw, manure, r similar material may be used in filling a gully if sufficient loosened irt is used to anchor and cover it.

On large gullies or in hard soils it may be necessary to use a bulldozer or explosives. Either may prove costly, and they should not e used indiscriminately. On large jobs the bulldozer will usually ove soil at a lower cost per unit volume, but it requires considerable verhead investment and equipment that is not available on the rdinary farm.

It should be kept in mind that in site preparation bank sloping is ecessary only to the extent of securing ground slopes and a surface ondition satisfactory for planting or seeding. Usually planting and eeding can be done and a satisfactory growth produced without ny extensive bank sloping. The ground should be left in a roughned condition for either planting or seeding.

NATURAL REVEGETATION

Any gully, no matter how large, and regardless of its condition, ill usually be reclothed with vegetation, provided it is properly rotected and is in a locality where vegetation will grow. If the ater that causes the gully is diverted and livestock, fire, or any other ause of disturbance kept from the gullied area, plants begin to come . At first they come very slowly because it is hard for them to get foothold. Later, when the pioneer plants have improved the soil omewhat, other plants appear. The whole natural process may ake many years in the drier parts of the country, but where there is ore moisture, the process is more rapid.

Plants will always come in naturally on protected areas, but on ullied land there are several things that slow down the final healing f the erosion scar. One is the continued loss of soil caused by freezg, thawing, and washing (fig. 2, *C*). This loss cannot always be topped, but it can often be reduced by the use of a mulch of boughs, traw, or leaves, which also assists in catching and holding plant eeds. Another thing is the steepness of some gully banks. Until he steep sides cave in and reach a gentler slope (about a 1:1 slope), is difficult for plants to root themselves. Unless large gullies with teep banks are plowed in, pushed in with a bulldozer, or dynamited, may take many years for them to become stabilized.

In spite of conditions such as these, hardy, thrifty plants capab of surviving in gullied areas will generally appear naturally. S called "weeds" will usually come first. They prepare the way f other plants, which always follow them in a year or two. Give sufficient time, this natural process will eventually reclothe the gul with the predominant vegetation of the region, whether that be tree brush, or grass. Frequently this opportunity to obtain a chea protective covering is overlooked and unnecessary expenditures a made for structures or plantings. Many previously active gulli have been completely stabilized by a natural growth of vegetatio that sprang up after the land was abandoned and livestock exclude (fig. 13). Natural revegetation, however, may be a lengthy proces

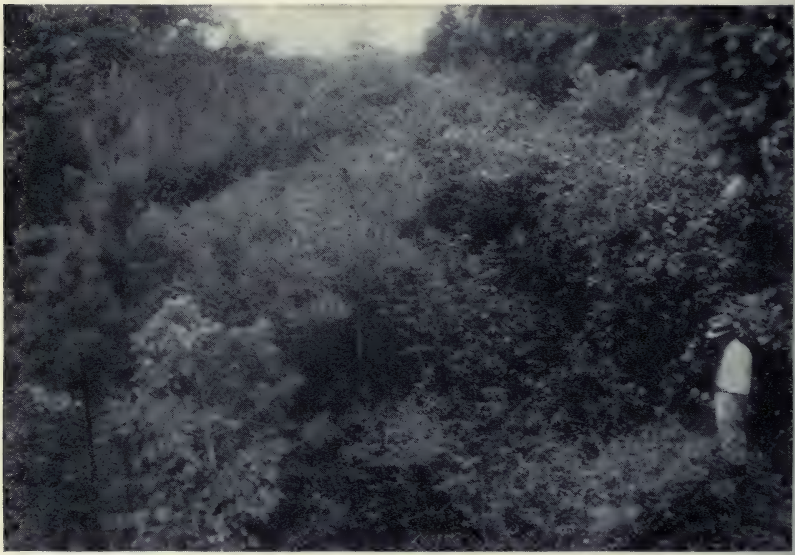


FIGURE 13.—Plants that come in naturally are usually very hardy and thrift They have completely stabilized this gully, which originally was about feet deep.

Where natural growth does not appear to be able to cope with existin erosion or where certain plant species of economic value are desire it may be necessary to consider ways and means of establishing veg tation artificially.

PLANTING AND SEEDING FOR REVEGETATION

CHOICE OF PLANTS

So far as erosion control alone is concerned, it makes little differen whether trees, shrubs, vines, or grasses are used in a gullied are Any of these, if well-established, provides good protection for soi Consequently, the kind of vegetation to use is best chosen on a bas of what the planted area will be used for when it is stabilized.

A stabilized gully can be used as a woodland area, as a wildli habitat, as a drainageway for water, or as pasture land or hay lan It should not be cultivated, however, nor should it be burned, brushe or used in a way that will promote erosion. If it is to be used as drainageway, grass is ordinarily the primary cover (fig. 14). Gras od can carry more water safely and at higher speeds than can woody lants. A sodded drainageway can be crossed with farm machinery, hereas one with a woody cover cannot. Grassed drainageways produce good yields of hay in some sections. If they are utilized as pasture, razing should be regulated. It should not be forgotten, however, that ood grass growth demands a well-prepared seedbed and reasonably rtile soil, a condition rarely present in gullies.

IGURE 14.—A growth of bluegrass and black walnut trees protects this gully. The gully is used to carry surface run-off from an adjacent field.

In certain regions trees and shrubs are easier to establish in guled areas than grasses, but they should not be used in drainageways nless the amount of water flowing in the channel is relatively small ig. 15). Trees on a gullied area will produce a crop of fence posts r rough timber for general use about the farm. Shrubs are used articularly to attract wildlife, especially insect-eating birds, if ne gully is near cropland, although many trees and grasses are also aluable to wildlife.

Where severely eroded and gullied areas must be retired from crop nd or pasture land, woody plants are usually used to help stabilize

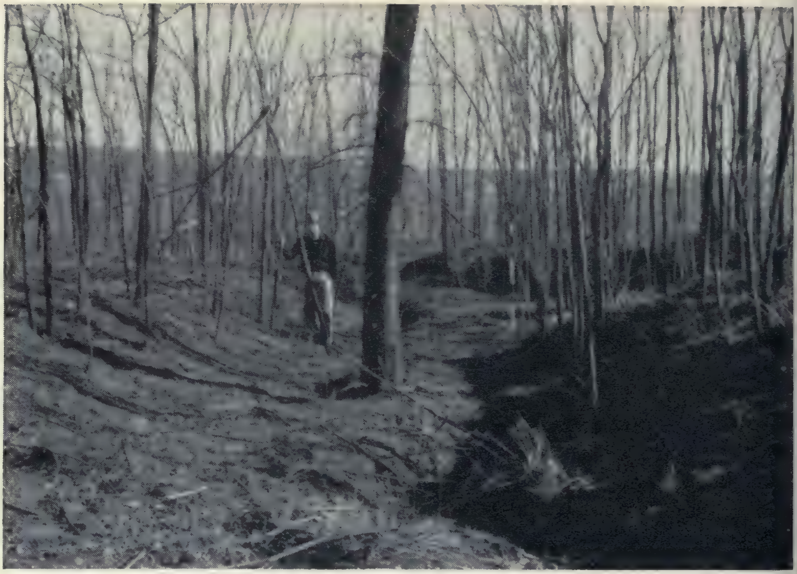


FIGURE 15.—A 10-year growth of black locust trees has completely stabiliz this gully, which originally was about 17 feet deep. The gully carries ve little water.

them, and the areas are then ordinarily reclassed as woodland an wildlife areas.

TREES, SHRUBS, AND VINES

Preparation of area.—Before gullied areas are planted, they shoul be fenced from livestock unless they are in a field in which livestoc does not run. Trampling and grazing by domestic animals in thes critically eroding areas will prevent vegetation from forming a goo cover, which is essential in preventing washing.

The area to be fenced or otherwise protected should be larger tha the width of the gully. For example, if a gully is about 10 feet dee the distance from the fence to the nearest edge of the gully should 20 to 25 feet. It is better to allow an even greater distance at t gully head because at the head the erosion hazard is greatest.

Selection and planting of species.—The first choice of trees, shrub and vines for gullies should be plants that are native to the localit and grow on similar sites. These plants are already acclimated an thus have the best chance of survival under the harsh growing cond tions in gullies. If useful native plants are unsatisfactory, secon choice would fall on plants introduced from other areas or countrie

There are a number of native trees, shrubs, and vines that hav proved satisfactory in controlling gullies. Among trees may be liste black locust (*Robinia pseudoacacia*), catalpa (*Catalpa* sp.), Chine elm (*Ulmus parvifolia*), cottonwood (*Populus* sp.), green ash (*Fraxinu lanceolata*), hackberry (*Celtis occidentalis*), honeylocust (*Gleditsi triacanthos*), mulberry (*Morus* sp.), northern red oak (*Quercus borealis* Osage-orange (*Maclura pomifera*), pine (*Pinus* sp., in general), an willow (*Salix* sp.). Shrubs and vines that have proved effective i gully planting done by the Soil Conservation Service so far includ several shrub dogwoods and osiers (*Cornus asperifolia, C. stolonifer*

C. paniculata), viburnums (*V. lentago, V. dentatum,* and *V. trilobum*), chokecherry (*Prunus virginiana* and *P. demissa*), Russian-olive (*Elaeagnus angustifolia*), wild plum (*P. americana*), skunkbush (*Rhus trilobata,* paloblanco (*Forestiera neomexicana*), sugar sumac (*Rhus ovata*), and coralberry (*Symphoricarpos orbiculatus*), kudzu (*Pueraria thunbergiana*), and Japanese honeysuckle (*Lonicera japonica*). It should be mentioned that honeysuckle is of very little value to wildlife.

This list could easily be supplemented by other species, since there are many others that have been used successfully. Additional selections may be made from plants recommended by the local county agent.

In using woody plants it is well to remember that solid plantations of one kind are undesirable because they favor the spread of any insect or disease that may attack them. Neither do they encourage wildlife as much as mixed stands do. In mixtures of shrubs and trees, the shrubs should be placed on the less favorable sites, the trees on the better ones. Also, the whole gullied-area plantation may well be planted around its outer edge with two or more rows of shrubs of particular value to wildlife. These outer-edge rows also serve to protect the tree plantings within.

Vines are ordinarily not planted with trees and shrubs because they prevent the best growth of these woody plants by clambering over them. In some parts of the country, however, vines may be used satisfactorily in a gullied area (fig. 16).

The spacing of plants will depend on local conditions, but 6 feet apart in each direction is the maximum spacing ordinarily recommended for erosion control. Spacings of 3 by 3 feet and 4 by 4 feet are better for shrubs in the gully. On the edge rows along the banks 6 by 6 feet is satisfactory. No plants should be placed on very steep banks in steps cut in the bank. Nor should they be planted under overhangs or too close to edges of banks that will eventually cave in.

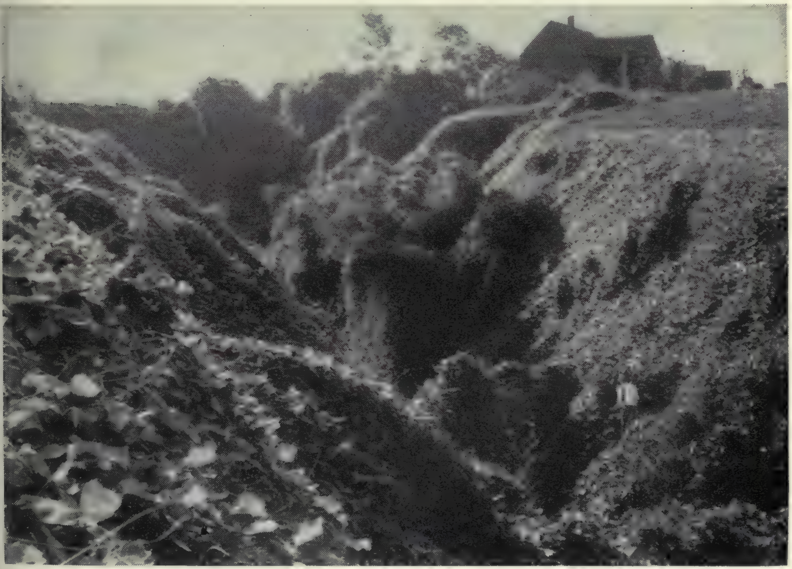


FIGURE 16.—This gully, originally about 35 feet deep, is well blanketed with a second-year growth of kudzu.

It is important to get good planting stock to transplant. Nursery grown stock has proved much better than wildings in most parts of th country. Because the gullied areas have such poor soil, the stronge and more thrifty the planting stock the greater the chance of establishing the plants the first time. Suitable nursery stock can ordinaril be obtained from local nurserymen or from State nurseries.

Just as with other crops, the use of fertilizer with trees or shrub placed in gullies assures increased survival and growth.

SHRUB CHECKS

In small or medium-sized gullies with small drainage areas it i frequently possible to construct checks consisting of shrubs place across the flow line of the gully (fig. 17). The shrubs are placed to 5 inches apart in shallow trenches and are sometimes protected b rows of stakes. The stakes are placed about 1 foot down the channe from the shrubs so that the plants will benefit from silt collected b the stakes. The shrub checks reduce water velocities in the gull channel and induce silting, which gives other vegetation a chance t become established. Shrub checks should be closely spaced if the are to be effective. They should be used only in gullies that have mild grade.

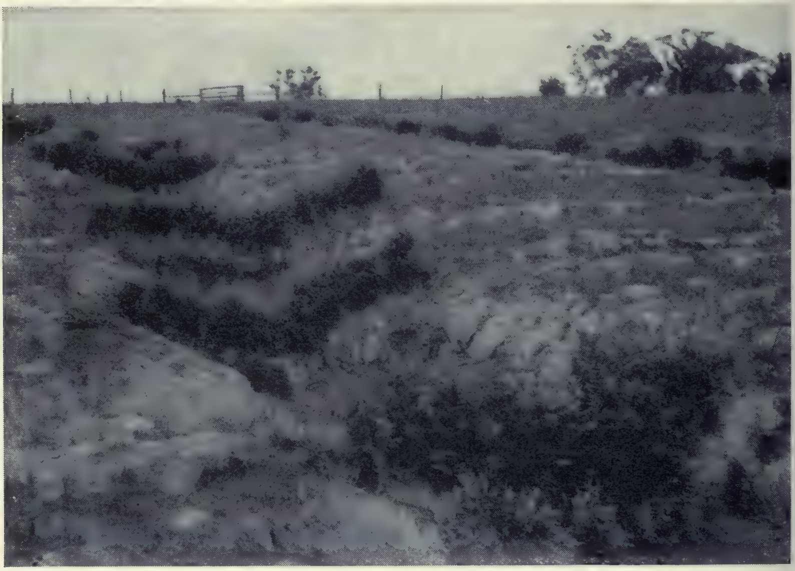


FIGURE 17.—Shrub checks in a small gully. Note the close spacing of the check

WILLOW CHECKS

Another type of check frequently used in gullies with small drainag areas and of moderate slope is constructed of willows. Willows ar used only in locations where the soil is naturally moist throughout th year. Cuttings are made from green willow trees and set in row across the gully at intervals of about 1 foot. Sometimes several row are placed close together. These cuttings take root and form living check across the gully.

Further information on the use and planting of trees, shrubs, and vines in the control of gullies is given in various State publications and in Farmers' Bulletin 1788, Wildlife Conservation Through Erosion Control in the Piedmont.

GRASSES AND GRASS-LEGUME MIXTURES

Grass covers are usually preferable for scattered gullies in good pasture or in cultivated fields where the preparation of an adequate seedbed is not difficult.

Grass covers may be produced by seeding or by transplanting sod. The use of manure or commercial fertilizer is usually required for good growth. Wherever applicable, seeding is the cheaper method. Mulching the seeded areas with light covers of straw, cane, or fine brush conserves moisture and is beneficial in assisting grass seed to become established on these areas.

In seeding, it is generally advisable to use a mixture of adapted grasses and legumes to insure complete stands and early stabilization of the gully. As the less adapted species thin out, the more aggressive ones will spread to replace them and thus perpetuate a complete ground cover.

Among the grasses and legumes that have stabilized gullies, Kentucky and Canada bluegrass, redtop, Bermuda grass, clovers, annual and perennial lespedezas, Kikuyu grass, wheatgrasses, bromegrass, and Napier grass have been commonly used in areas where they are adapted. Many other plants may be used for the purpose, and the ocal county agent should be consulted before a selection is made.

Small or medium-sized gullies to be seeded in cultivated fields should be plowed in or otherwise partly filled in order to convert them into broad channels, which permit the water to spread. The spreading of water reduces its cutting power. After the channel has been properly haped, a firm seedbed should be prepared and fertilizers applied if hey are needed. Seeding may be done by broadcasting or drilling. f the seed is broadcast, the ground should be harrowed lightly afterwards to cover the seed and then firmed by packing. In the semiarid ections, drilling is much preferred to broadcasting because it places he seed in moist soil and thereby insures more rapid and uniform germination. If the drill is used, it is advisable to run it in a zigzag pattern, crossing the gully as often as conveniently possible. This will keep the drill rows from running with the gully and will reduce he danger of rilling between the rows. After the ground has been drilled, it should be firmed with a packer driven in a zigzag line. In onstructing drainageways of this kind it is poor economy to attempt o confine the channel to too small an area. The grasses should be eeded well out over the embankment, and it is desirable to leave the edge of the seeding irregular to prevent the formation of new gullies along the sides.

Grass and leguminous plants are very tender in the seedling tages, and every precaution must be taken to keep run-off water out of the newly seeded drainageway until the plants are well established. In addition to any permanent diversions that may have been installed, it is sometimes advisable to construct a temporary dike along the sides of the drainageway to exclude run-off until a good growth has been obtained. In the larger drainageways where such a dike would not be practical and where it is impossible to exclude all run-off in any other way, it is often advisable to plant a quick-growing annual crop to stabilize the drainageway before the grasses are seeded. Smal grains, Sudan grass, lespedezas, and similar cover may be seeded in the spring to hold the soil and produce a residue in which to seed the grasses the following fall. Nurse crops may also be seeded with the grasses to give quick protection, but care must be taken not to seed the nurse crop so thick that it will compete with the grasses for moisture or smother the small grass and leguminous plants.

SODDING

If an immediate grass cover is required and suitable sod is available it may be necessary to transplant sod. Sodding is generally too costly for extensive use over large gullied areas. Sod is needed, however, on critical sections at the gully head or at points along the bank or bottom where protection against waterfall erosion is necessary. It is also frequently used in connection with permanent structures. Grass covers can usually be established through sodding on areas exposed to run-off where it would be impractical to secure a cover by seeding Where the amount of run-off is not too large, and good sod is available it can be used as a substitute for the more costly masonry and concrete materials. Sod flumes, sod check dams, and sod spillways have all functioned satisfactorily when properly constructed and applied

TRANSPLANTING SOD

There are three general methods of transplanting sod: Solid sodding, broadcast sodding, and spot or strip sodding. Solid sodding consists of cutting the sod in strips and transplanting it as a continuous cover over the area to be sodded. The sod is usually cut in strips about 1 foot wide, 8 to 10 feet long, and 1½ to 2½ inches thick. The amount of time and labor required to cut the sod can be materially reduced by the use of special horse- or tractor-drawn sod cutters When transplanted, the strips are continuous and are usually laid on the contour or at approximately right angles to the direction of the water flow. It is desirable to staple the sod down or cover it with wire mesh if there is danger of heavy run-off before the sod can establish itself. Care must be exercised in cutting, placing, and tamping the sod. Solid sodding is the most costly type of sodding, but it provides a cover that is capable of conveying considerable run-off almost immediately after it is placed.

Broadcast sodding requires less labor and time, particularly if suitable equipment is available. The area from which the sod is to be taken is disked until the sod is well cut up and mixed with the topsoil This mixture of grass roots and topsoil is then collected and transported by scrapers or spreaders and spread in layers 2 to 3 inches thick over the area to be sodded. After it is placed, the area should be disked so as to work the sod into the soil on the new location. The fertile topsoil transplanted with the sod roots promotes a vigorous growth. Unfortunately broadcast sodding can be used in transplanting only grasses that spread by rootstocks, and it does not provide a surface cover capable of conveying run-off so soon as solid sodding It has been used with good results in transplanting Bermuda grass This method is relatively inexpensive.

Strip sodding and spot sodding are commonly used in transplanting od. In strip sodding, the strips of sod are ordinarily laid in trenches the same dimensions as the sod. Sometimes they are laid at regular tervals across the slope to be sodded, and the intervening areas are led with topsoil and seeded. In either arrangement the top of the od strip should be flush with the top of the adjacent ground surface.

Spot sodding consists of transplanting small clumps of grass, root- ocks, or stolons at random over the area to be sodded. These are sually placed in small holes.

Strip sodding and spot sodding give quicker coverage with less sod ian solid sodding, but they require a longer time to provide complete rotection. They give the most satisfactory results with grasses that read rapidly by stolons or rootstocks and when used as a means of tablishing grass cover on gully bottoms or sides not exposed to ccessive run-off.

Sod should be obtained from areas where its removal will not cause rious erosion, or it should be removed in such a manner as to mini- ize later erosion damage. On sloping land it should be removed only alternate strips at right angles to the land slopes. Leaving un- sturbed contour strips at intervals will usually give sufficient pro- ction to prevent harmful washing until the bare areas are revege- ted. For transplanted sod the need and value of liberal applications farm manure or commercial fertilizer should not be overlooked. he ultimate success of any sodding is dependent on a vigorous rowth. If the plant food necessary to assure good growth is not rovided on infertile soils, all control efforts may be wasted. The sual procedure is to apply the fertilizer over the area to be sodded efore the sod is laid.

SOD FLUMES

Sod flumes may be successfully used to control overfalls in gullies ith heads less than 10 feet and drainage areas less than 25 acres. iitable sod must, of course, be available. In areas of good Bermuda rass or Kentucky bluegrass, sod flumes have been successfully used larger watersheds in gullies that have low overfalls. A flume merely rves the purpose of preventing further waterfall erosion by providing protected surface over which the run-off may flow into the gully ig. 18). It is not intended to fill a gully or to stabilize the gully iannel or sides below the flume.

The overfall to be sodded must be cut back to a slope flat enough to ake possible the establishment and maintenance of a permanent ant cover. The allowable slope will depend on the soil type, size of atershed, height of the overfall, and the quality and type of sod sed. Generally a 4:1 slope should be about the steepest. To avoid estructive velocities through the flume it should be wide in proportion its depth and should have sufficient cross-sectional area to carry ie expected run-off at nonerosive velocities. A width of at least 5 inches per acre of watershed is desirable, and the maximum depth flow expected over the flume should seldom exceed 12 inches.

Unless the anticipated run-off is small, solid sodding is usually nec- ssary for sod flumes. It is important that the gully channel below ie flume be on a stable grade. If it is not, overfalls may develop elow the flume and undermine the sod. On small watersheds that

have erosion-resistant soils, an unprotected gully channel may be re
sonably safe for grades of as much as 1½ percent. Channels protect
by vegetation can generally withstand considerably higher grade
On the more erodible soil types and larger watersheds unprotect
channel beds should usually have a fall of less than 1 foot per hundr
feet of length. Unstable grades may be reduced by mechanical mea
ures if it is impracticable to provide the necessary protection
vegetation.

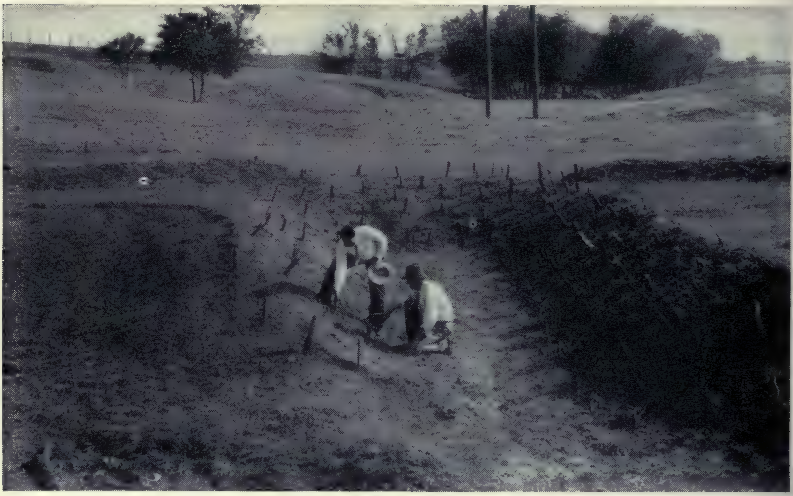


FIGURE 18.—A gully head controlled with a sod flume. The transplanted s
has been staked and wired down so the grass roots will have an opportuni
to catch. Note the earth lead-in dikes at the top of the ramp.

SOD CHECKS

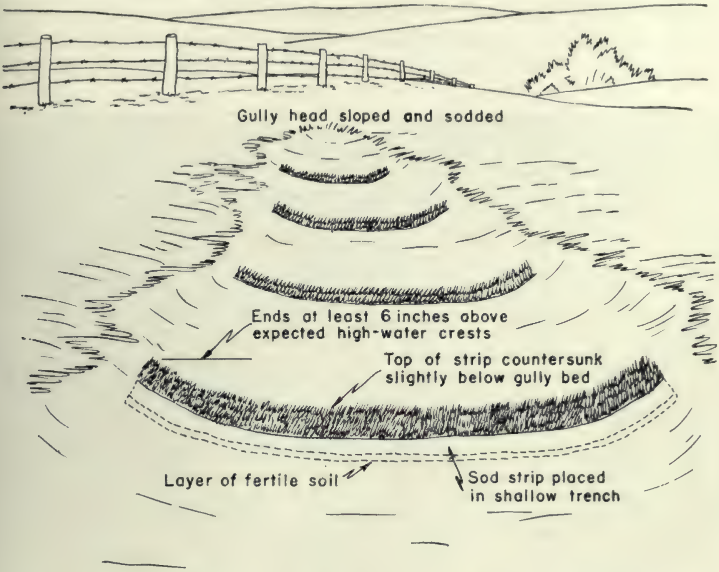
Sod checks are frequently used to stabilize gully channels until t
intervening areas become vegetated. The several types are mere
variations that are made necessary by existing gully conditions a
required protection. Two of the more important are the sod str
and the sodded earth fill.

The sod-strip check is best adapted to small gullies (fig. 19) th
have small- to medium-sized watersheds and relatively flat chann
grades. The strips are laid across the gully channel so that each str
when set will be flush with or slightly below the bed of the gull
The strip should have a minimum width of 12 inches and should e
tend up the gully sides at least 6 inches above expected high-wat
crests. (See table 1 for expected run-off.) The spacing of the stri
will depend on the spreading characteristics of the sod, the draina
area, and the grade of the gully. Spacings of 5 to 7 feet are common
used. Where it is difficult to establish vegetation on gully sides, co
tour sod strips may sometimes be used to advantage.

SODDED EARTH FILLS

Low, sodded earth fills (fig. 20) can often be advantageously use
as a substitute for ordinary brush or wire check dams in stabilizi

ully channels. Where suitable sod is available they can be contructed at less expense; and they have an additional advantage beause of the fact that by their use vegetation is immediately estabshed at intervals along the gully. They have been successfully used


Gully head sloped and sodded
Ends at least 6 inches above expected high-water crests
Top of strip countersunk slightly below gully bed
Layer of fertile soil
Sod strip placed in shallow trench

IGURE 19.—A series of sod-strip checks in a small gully. These checks cannot be used in gullies with steep grades.

small- to medium-sized gullies with drainage areas of less than 25 cres. The earth fills should be located at strategic points or at reglar intervals along the gully, as is necessitated by existing conditions. requently these fills are spaced so that the top of each will be as igh as the base of the next one above. Side slopes steeper than 3:1 the upstream side and 4:1 on the downstream face should seldom e used. The fill should be well tamped, and heights in excess of 18 ches should be avoided because of the overfalls created. An averge height of 10 or 12 inches is commonly used. The top of the fill ould be low in the center and should gradually curve upward to eet the gully sides and provide the necessary spillway capacity. The ll should be solid-sodded on the top and on the downstream face, and should be carried up the gully sides to a height of 6 to 12 inches bove maximum water crest expected over the structure.

STRUCTURES

Structures are used in gullies to facilitate the establishment of vegeation or to provide permanent protection at points that cannot be dequately protected in any other way. They are usually used only gullies through which run-off must be conveyed. If the run-off that ust be conveyed through gullies is not in excess of the amount that an be handled by well-established vegetation, temporary mechanical structures may be used in the gullies until the vegetation becomes e tablished. Such material as brush, poles, wire, and loose rock a usually used for constructing temporary check dams. If the run-o is of sufficient volume to make ultimate control by vegetation impra ticable, permanent mechanical control measures will have to be use These structures, built to give permanent reinforcement to vegetatio should be made of durable materials; reinforced concrete, masonr metal, or earth. They should be used only where less expensive mea

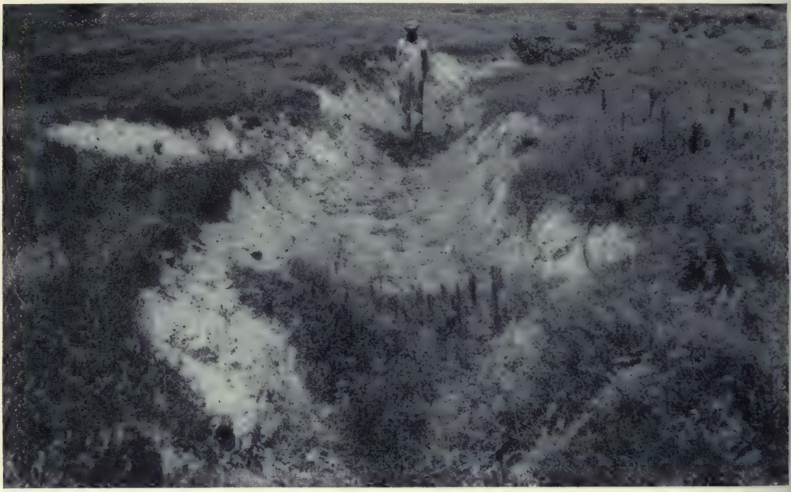


FIGURE 20.—Sodded earth fills in a small gully. The fills are solid sodded a closely spaced. Their average height is about 10 inches.

are impracticable and should be supplemented by vegetation wherev possible.

The proper use of structures in gullies requires good judgment determining the need for them and the extent of their use. It is ju as great a mistake to attempt to control a gully without structur assistance in areas where structures would ultimately provide the mo satisfactory control as it is to use structures in gullies that could stabilized more economically with vegetation alone. Temporar structures do not require such good materials as permanent structure nor is so much precision in construction necessary. A permane structure usually costs more than a temporary structure, and its failu is therefore a greater loss.

TEMPORARY CHECK DAMS

Temporary check dams are used to collect and hold soil and moistu in the bottom of sterile gullies so that vegetation can be establishe They may also be used to check temporarily erosion in the gully hea or in the channel of a gully until a protective cover of vegetation ca be produced. If run-off from the contributing drainage area is d verted from a gully or retained on the watershed or if a gully h advanced to the drainage divide, any check dams used in it wou act primarily as obstructions to hold silt and the precipitation occurri on the immediate area. As they would not be exposed to any appr iable amounts of run-off, construction could be simplified considerbly. Piles of closely compacted rock and brush are all that is ecessary across the bottom of the gully if run-off is negligible.

Where temporary structures have been used to control gullies, it as been found that several low check dams are more desirable than ne large dam of equivalent height. Low dams are less likely to fail, nd after they silt up and rot away, the vegetation can protect low overdls at these sites much easier than high ones. A temporary dam nould seldom exceed 15 inches in overfall height, and an average ffective height of about 10 to 12 inches will be better. By effective eight is meant the vertical distance from the original gully bed to ne spillway crest of the structure. It requires considerable field udgment to determine the most satisfactory location and spacing or temporary check dams. They may be located on definite intervals nd spacings, but usually they are constructed at strategic locations as to protect and facilitate plant growth at critical points. In this ay effective results can be produced with fewer dams.

Temporary dams are used most successfully in gullies that have nall drainage areas. The total amount of soil collected by these ams is relatively small, but they hold enough to promote the growth f some vegetation, which in turn forms a barrier that collects more oil. The dams should be constructed far enough into the bottom nd sides of the gully to prevent wash-outs underneath or around the nds of the checks. They should also have sufficient spillway capacity convey run-off at the maximum rate that can be expected during ne life of the structure. An apron will generally be necessary to rotect the structure from the undermining action of the run-off as is discharged from the spillway.

The life of temporary structures will, of course, depend on the ocality, the quality of the materials, and the construction procedure sed, but under ordinary field conditions these structures should last om 3 to 8 years. Spillway capacities are usually designed for rainfall ntensities having a frequency of 5 to 10 years. To determine the notch ze required, the size and nature of the contributing drainage area an be determined in the field and the probable amount of run-off elected from table 1. The size of the rectangular spillway notch equired to handle this run-off can be taken from table 3. As a aargin of safety, the depth of the notch should generally be made bout 5 to 6 inches deeper than the actual dimensions necessary to onduct the run-off without overtopping. The notches should be nade as wide as practical in proportion to the depth in order to avoid nnecessary concentration of the water as it passes over the structure. t is desirable to have the notch length at least several times as great s the depth. With certain types of check dams a curved or a riangular notch is often the most practical.

Suppose it is desired to know the size of a rectangular spillway that ill carry a discharge of 32 cubic feet per second. From table 3 it will e noted that it is possible to use several different combinations of epth and length to obtain this discharge. For example, any one of ne following notches would be large enough to carry an approximate ischarge of 32 cubic feet per second: 1 foot deep by 10 feet long; .5 feet deep by 6 feet long; 3.0 feet deep by 2 feet long.

Since it is desirable to spread the water as much as possible in order o avoid undue concentration of water downstream from the structure and to keep the depth of the water that goes over the dam as low a possible, the best notch size, if the channel width permits, is the on first listed, namely, 1 foot deep by 10 feet long. If a 6-inch margi of safety is added to this depth, the size would be 18 inches deep b 10 feet long.

TABLE 3.—*Approximate discharge capacity* [1] *of rectangular weir notches in smal temporary and permanent check dams*

Depth [2] of notch (feet)	Discharge capacity of spillways having a length [3] of—											
	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet	22 feet	24 fee
	Cubic feet per second	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet per second*	*Cubic feet pe secon*
0.5	2.3	4.5	6.8	9.1	11.3	13.6	15.8	18.1	20.4	22.6	24.9	27.
1	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6	64.0	70.4	76.
1.5	11.8	23.5	35.2	47.0	58.8	70.5	82.3	94.1	105.8	117.6	129.3	141.
2	18.1	36.2	54.3	72.4	90.5	108.6	126.7	144.8	162.9	181.0	199.1	217.
2.5	25.3	50.6	75.9	101.2	126.5	151.8	177.1	202.4	227.7	253.0	278.3	303.
3	33.3	66.5	99.8	133.0	166.3	199.5	232.8	266.0	299.3	332.5	365.8	399.
3.5	41.9	83.8	125.7	167.6	209.5	251.4	293.4	335.3	377.2	419.1	461.0	502.
4	51.2	102.4	153.6	204.8	256.0	307.2	358.4	409.6	460.8	512.0	563.2	614.
4.5	61.1	122.2	183.3	244.4	305.5	366.6	427.7	488.8	549.8	610.9	672.0	733.
5	71.6	143.1	214.7	286.2	357.8	429.3	500.9	572.4	644.0	715.5	787.1	858.

[1] The discharges that must be designed for may be obtained from table 1 for the different watersheds For discharges in excess of those shown the length may be increased proportionately if the same head i maintained.

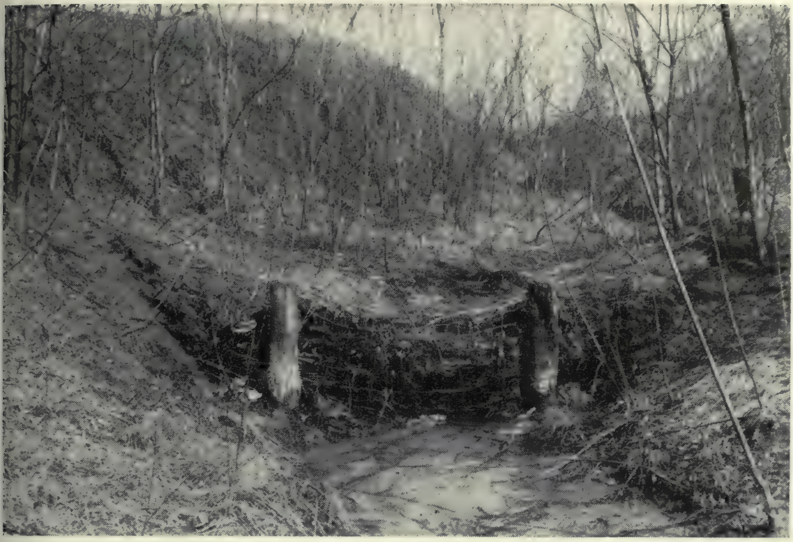
[2] The depth is indicated by *d* in the drawings.

[3] The length is indicated by *l* in the drawings.

The temporary check dams most commonly used in gullies are th woven-wire dam, the brush dam, the loose-rock dam, and the plan or slab dam. Each name indicates the principal material used in th dam. There are numerous variations in the way each of these chec dams can be constructed. Satisfactory dams may also be constructe from materials other than those listed or from a combination of thos materials. The type selected for use on any particular job depend primarily on the materials available. If several types of suitabl materials are available the size and characteristics of the gully will b important considerations in selecting the structure. Often the builde prefers to construct a certain type of dam.

WOVEN-WIRE DAMS

Woven-wire dams (fig. 21) are widely used because of the eas with which they can be constructed, the availability of material, an the possibility of using them in different types of gullies. They ar used in gullies of moderate slope and small drainage area. The dam i commonly built in a somewhat crescent or half-moon shape, with th open end upstream. This allows for a longer spillway than is possibl on a straight dam and at the same time protects the ends of the dam The amount of curvature is not fixed by rule. An offset equal t about one-sixth of the width of the gully at the dam site will generally provide sufficient curvature. For example, if the gully is 24 feet wide, the spillway of the dam would be about 4 feet downstream from the abutments. A row of posts is set along the curve of the proposed dam at about 4-foot intervals and 2 to 3 feet deep (fig. 22). One interval should fall near the center of the gully to form the central portion of the spillway. A trench about 6 inches deep and of about



GURE 21.—This woven-wire dam is used to aid in establishing vegetation.

e same width is dug along the upstream side of the row of posts. eavy-gage woven wire is placed against the posts, with the lower rt set in the ditch so that 10 to 12 inches projects above the ground rface along the spillway interval. It is desirable to place the coarse esh on the bottom. The wire should be securely stapled to the posts. the top of the wire is kept approximately level along the central terval used for the crest of the spillway a much better spreading of ater will be obtained as it passes over the structure.

If plenty of rocks are available they may be used for the apron; herwise brush or sod is generally used. The brush is anchored by lling the butt ends through the wire mesh, where both the fill and ojecting branches will help to hold it. Enough brush is laid to make apron at least 4 feet long and extending at least 2 feet on each side the posts that form the level portion of the spillway. Sometimes a pole anchored to stakes is placed across the center of the apron to mpress the brush. It is desirable to countersink the apron and to e shorter brush near the upper end to produce a shingle effect. layer of fine mulch underneath the apron is recommended so that a ser bond with the earth can be secured.

To promote rapid filling and to seal the structure, straw, fine brush, similar material should be packed against the wire on the upstream le to the height of the spillway crest. This should be backed with well-tamped earth fill of at least a 2:1 slope. Sodding along the illway crest has proved helpful in preventing channeling along the . For spillway dimensions, see table 3. The minimum value of *d* g. 22) should be 18 inches.

BRUSH DAMS

Brush dams are best suited for gullies with small drainage areas d with soil conditions that permit the driving of necessary anchor-

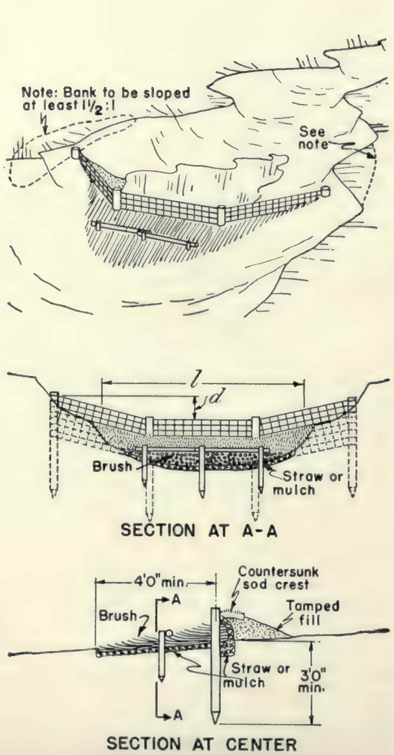

Note: Bank to be sloped at least 1½:1
See note
l
d
Brush
Straw or mulch
SECTION AT A-A
4'0" min.
A
Countersunk sod crest
Tamped fill
Brush
Straw or mulch
3'0" min.
A
SECTION AT CENTER

FIGURE 22.—A woven-wire dam.

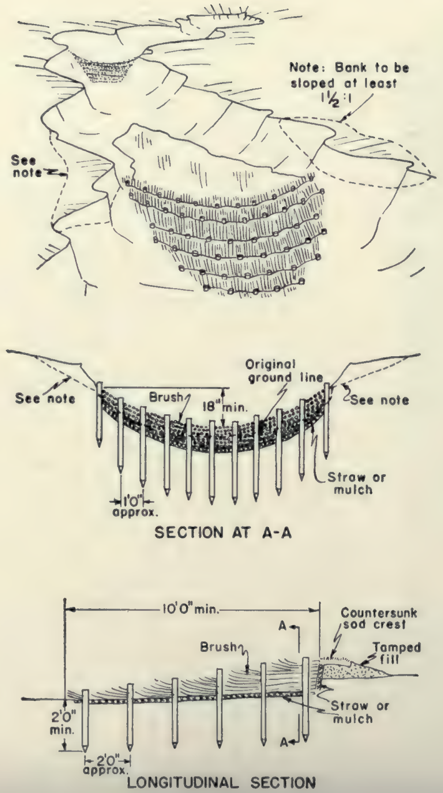

Note: Bank to be sloped at least 1½:1
See note
See note
Original ground line
Brush
18" min.
See note
Straw or mulch
1'0" approx.
SECTION AT A-A
10'0" min.
A
Countersunk sod crest
Tamped fill
Brush
Straw or mulch
2'0" min.
2'0" approx.
A
LONGITUDINAL SECTION

FIGURE 23.—A brush dam in common use.

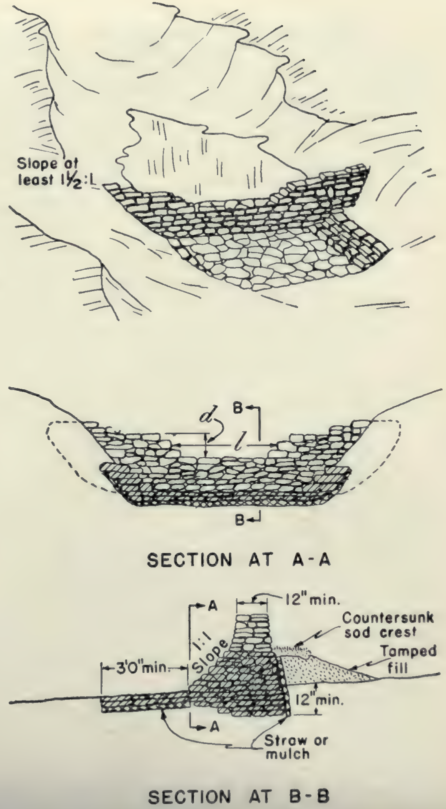
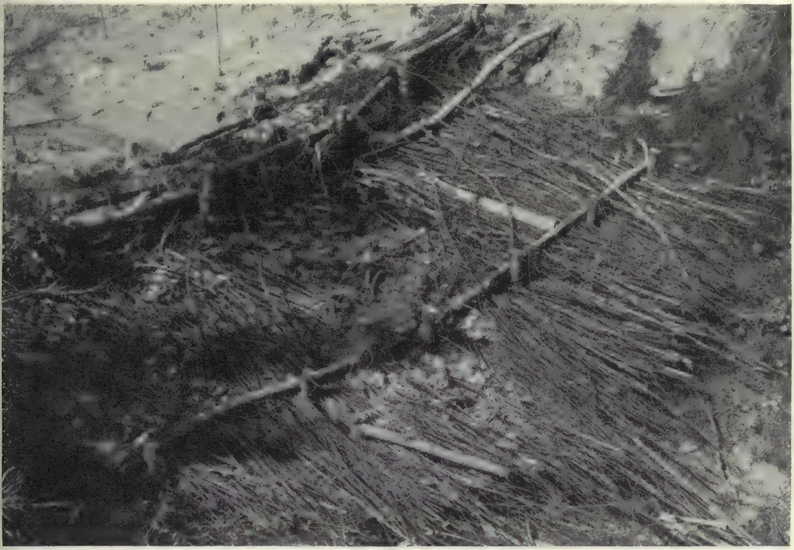

Slope at least 1½:L
d
B
l
B
SECTION AT A-A
A
12" min.
Countersunk sod crest
Tamped fill
3'0" min.
1:1 Slope
12" min.
A
Straw or mulch
SECTION AT B-B

FIGURE 24.—A loose-rock dam.

g stakes. These dams are cheap and are easy to build. For is reason they are used in most sections of the United States where rush is available. Many kinds of brush dams are in use; the kind hosen for a particular site depends on the amount of brush available nd the size of the gully to be controlled. Whatever type is used, it is nportant that the center of the dam be kept lower than the ends to low water to flow over the dam rather than around it. The minimum nter height for spillway capacity is indicated in figure 23.



GURE 25.—A well-constructed brush dam in a small gully. Note the silt deposit above the structure.

The sides and bottom of the gully for a distance of 10 to 15 feet along ne site of the structure are covered with a thin layer of straw or similar ne mulch, which is slightly countersunk in order to form a bond etween the structure and the soil. Brush with butts pointing upream is next packed closely together over the mulch to about onealf of the proposed height of the dam. Several rows of stakes are nen driven crosswise of the gully, with the rows about 2 feet apart and ne stakes 1 to 2 feet apart in the rows (fig. 25). The stakes should tend up the sides of the gully and should be driven only partly in at rst. The brush fill is then completed and heavy galvanized wire retched along the rows of stakes and fastened to them. When this as been done, the stakes are driven down until the wire firmly comresses the brush in place. Several large rocks are sometimes placed n top of the brush in order to keep it compressed and in close contact ith the bottom of the gully. The center of the dam should be made w enough to provide the necessary spillway capacity.

LOOSE-ROCK DAMS

Loose-rock dams (fig. 24) are desirable where plenty of suitable rock available. They are used in gullies of moderate slope that have nall to medium-sized drainage areas. A well-constructed loose-rock am can be made more durable than the other types of temporary dams because rock will outlast brush, wire, or slabs. It also has a advantage because its flexibility and weight constantly hold it i contact with the bottom of the gully. The best structures can b built from flat stones, which are commonly known as flagstone With practice these can be so laid that the entire structure will b keyed together. If round or irregularly shaped rock must be used the structure is usually encased in woven wire so as to prevent th outside rock from being washed away. Irregularly shaped rock should preferably be placed in such a way that voids will be reduce to a minimum. If considerable time must be spent to fit the rock in laying up the dam, it is cheaper and more effective to construct rubble masonry dam or a concrete dam.

For the loose-rock dam an excavation is made across the gully to depth of about 12 inches (fig. 24). This forms the base of the dam on which the laying of the rocks is begun. The rocks are laid in row across the gully with sufficient overlap to produce a shingle effect an are brought to the required height. The center of the dam is kep lower than the sides to form the spillway. Several large flat rock countersunk below the spillway so as to be flush with the channel surface will serve as an apron. These should extend at least 3 feet downstream from the base of the dam. For the size of the spillway notch see table 3.

PLANK OR SLAB DAMS

Plank dams or slab dams (fig. 26) can generally be used in gullie with somewhat larger drainage areas than can the woven-wire o brush dams. They are constructed of planks, heavy boards, slabs or railroad ties. These dams can generally be constructed with les labor than other types of temporary dams and are particularly applicable in areas where there is appropriate material. If a group o these dams is to be placed in a gully the head wall can readily be constructed to required dimension at the farm shop or some other convenient location and later dropped, as a complete unit, into a suitabl trench across the gully.

In building the dam, posts are set in a row across the gully to depth of about 3 feet and about 4 feet apart. The posts should be s arranged that one of the intervals between posts will occur in th approximate center of the gully to form the spillway. After the post are set, a narrow trench is dug along their upstream side. The trenc is made about 1 foot deep and just wide enough to permit placing o the head wall and a thin layer of straw or grass as a seal. If th planks are close fitting or the slabs overlapped, the seal material ma not be necessary. The required spillway notch is cut out after th dam is constructed, or a suitable opening can be left at the top of th head wall during construction. Spillway dimensions are specified i table 3. A well-tamped earth fill is next made against the upstrea face of the head wall and brought to the height of the spillway crest This fill should have a slope not steeper than 2:1 and should exten well up on the gully banks.

The final stage in construction is the apron. If suitable rock i available a rock apron is easy to construct and will give satisfactor results. A brush apron might also be used. Where a plank apron i necessary, an area extending at least 18 inches on each side of th spillway notch and downstream at least twice the effective height o the dam, is excavated to a depth of 2 to 3 inches. A thin layer o nulch or gravel is spread over this area, on which the apron planks are hen placed. One end of the planks is butted against the downstream ace of the head wall and the other fastened to a toe log. A baseboard hould be placed above the juncture of the apron and the head wall as protection from water running over the spillway. The side walls of he apron are formed by laying up additional planks parallel to the pron floor and conforming with the slope of the gully sides. If roperly laid, the top of the apron floor at the lower end will be flush ith the surface of the gully channel. Sod is sometimes used for the pron if the drainage area is small and sod of good quality can be btained. The life of this type of dam may be greatly increased if the ood used is first creosoted.

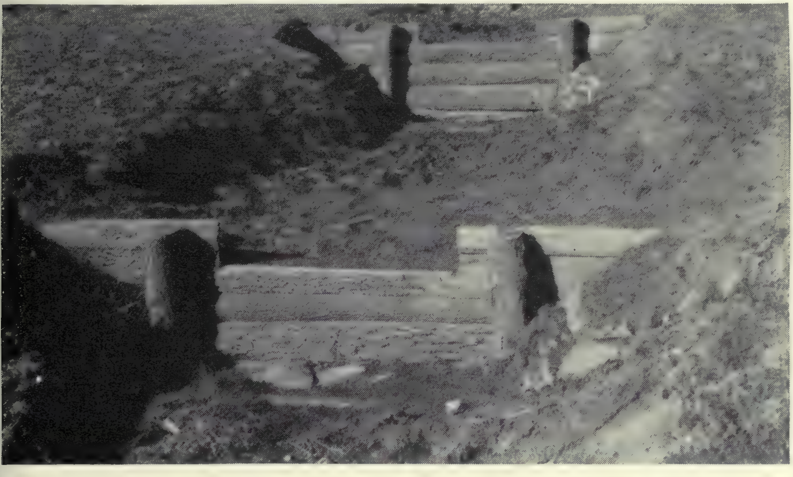


FIGURE 26.—Slab dams in a small gully.

Log and pole dams are sometimes used, but it has been found that he construction cost of these dams is generally higher than that of oven-wire, brush, loose-rock, plank, or slab dams. Some difficulty as also been experienced in getting a good bond between the log or ole structures and bottom and sides of the gully. If proper care is xercised, however, such dams can be used satisfactorily. Poles or gs are in some localities the only material available for the construcion of temporary check dams. On favorable sites dams constructed rom willow poles have proved satisfactory. The poles should be cut rom green willow trees. This dam would be similar to the check onstructed from willow cuttings that is described under shrub checks. owever, the willow-pole dam is built with a regular spillway notch rmed from the poles.

PERMANENT SOIL-SAVING DAMS

Permanent structures are those that are constructed from more urable materials, such as reinforced concrete, masonry, and earth. hese structures are used in gullies where temporary dams are either adequate or impractical. In certain areas rock-filled crib dams and ams constructed from railroad rails have been used. Such structures re usually classified as semipermanent.

Permanent dams are frequently necessary in gullies that must b retained as permanent waterways. Gullies from which the wate cannot be diverted are generally very active if their drainage area are large, and they also are hard to control without some permanen structure. Even a small amount of water going over a 15- or 20-foo overfall will produce enough energy to make the possibility of contro by vegetation alone questionable. A gully just beginning to cu back into a large drainage area (fig. 27) should usually be controlle by permanent structures in order to protect the area above fron further destruction.

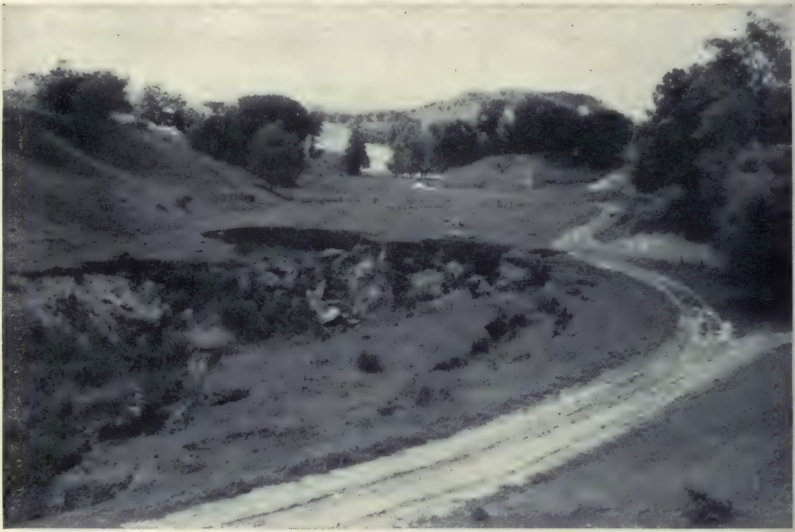


FIGURE 27.—If uncontrolled, this gully will eventually destroy much valuabl land because water from hundreds of acres of farm land drains into it.

The variety of conditions in gullies necessitates the use of severa types of permanent structures. Dams with regular notch spillway are usually built in locations requiring low structures. Where th run-off must be brought down from high overfalls, multiple-drop dams flumes, or drop-inlet dams are usually used. Generally, neither th masonry nor the concrete notch-spillway dam should be used to contro overfalls in excess of 8 feet.

The selection of the structure to be used for any particular job i largely a problem of determining the type that will provide the neces sary capacity and meet other requirements and yet give the mos economical construction costs. Large dams represent a sufficient in vestment to warrant special precautions. Considerable skill is re quired to build permanent structures. It is recommended that fo the building of concrete or masonry dams with an effective height o over 5 feet the services of a person skilled in design and constructio be obtained. If this is not practicable, the plans should at least b reviewed by him. The construction of small earth dams usually doe not present the foundation problems encountered with concrete o masonry dams. For this reason earth dams can ordinarily be buil to heights of 12 to 15 feet without serious difficulty.

Most States have laws governing the design and construction of ams that exceed certain heights or that impound water beyond a fixed mount. Anyone planning to construct a dam should familiarize himelf with all local and State regulations affecting such an undertaking.

To check the advancement of gullies effectively, permanent control tructures must be located near enough to the gully head so that the rade from the spillway crest to the ultimate lip of the gully will not xceed the silting grade that can be expected for the particular soil ype and cover (fig. 28). This grade may range from ½ to 3 percent r more, depending on the extent to which the future growth of egetation in the channel above the structure may tend to increase he natural soil gradient. Permanent structures should also be ocated so that the line of discharge from the spillway will be parallel o the center line of the gully immediately below the dam. This ill prevent side cutting of the drainage channel below the structure.

With permanent dams the discharge quantities and velocities are elatively high, so channel grades below or between permanent strucures should be almost flat, seldom exceeding a slope of 1 percent nless the channel bed contains sufficient rock to prevent harmful couring. The stability of a structure is dependent upon stabilized rades in the channel below. Excessive grades lead to the developent of channel overfalls, which gradually advance and undermine tructures. Steep grades maintained by a plant cover are generally ot dependable enough to be relied upon below permanent structures. xcessive downstream grades can be reduced by changing the location f the structure, by excavating and constructing the spillway apron o a lower elevation, or by constructing one or more permanent check ams in the channel below.

It is important that a firm foundation be secured for permanent tructures. Generally, wet foundations should be avoided, especially ith earth dams. Surface soil and organic matter should be removed rom the dam site to get a good bond between the structure and the npervious foundation material. Cut-offs should be extended into he bottom and sides of the gully to provide a more complete seal. n apron of sufficient length, width, and depth to prevent underining is necessary in the bottom of the gully below the dam. Care ust be exercised in selecting and placing the construction materials o that an impervious structure can be assured. Carelessness in onstruction will result in a weak dam and may lead to failure of the ntire structure.

The size of structures to be used is largely determined by the run-off apacity required, the height of overfall to be protected, and the idth of gully at the selected site. Since there is generally less danger f failure with low structures and since for low structures somewhat ore simple design and construction procedure can be used, it may ometimes be advisable to construct two or more low structures nstead of one high structure. The practicability of this substitution s largely dependent on local terrain and conditions in the gully.

The smaller permanent dams should be designed to withstand ntensities of rainfall that may be expected to occur once in 10 to 15 ears. As the larger permanent dams require greater expenditures, hey should be designed for intensities that have frequencies of 25 to 0 years or more. The type of structure used will also have some nfluence on the selection of the rainfall frequency. Local conditions and the judgment of the individual in charge of the construction work enter into the selection of design specifications for the various structures. The run-off that may be expected from drainage areas of various sizes under intensities of rainfall of a 10-year frequency is given in table 1. The sizes of rectangular notches required for structures with this type of spillway are given in table 3. In estimating the acreage

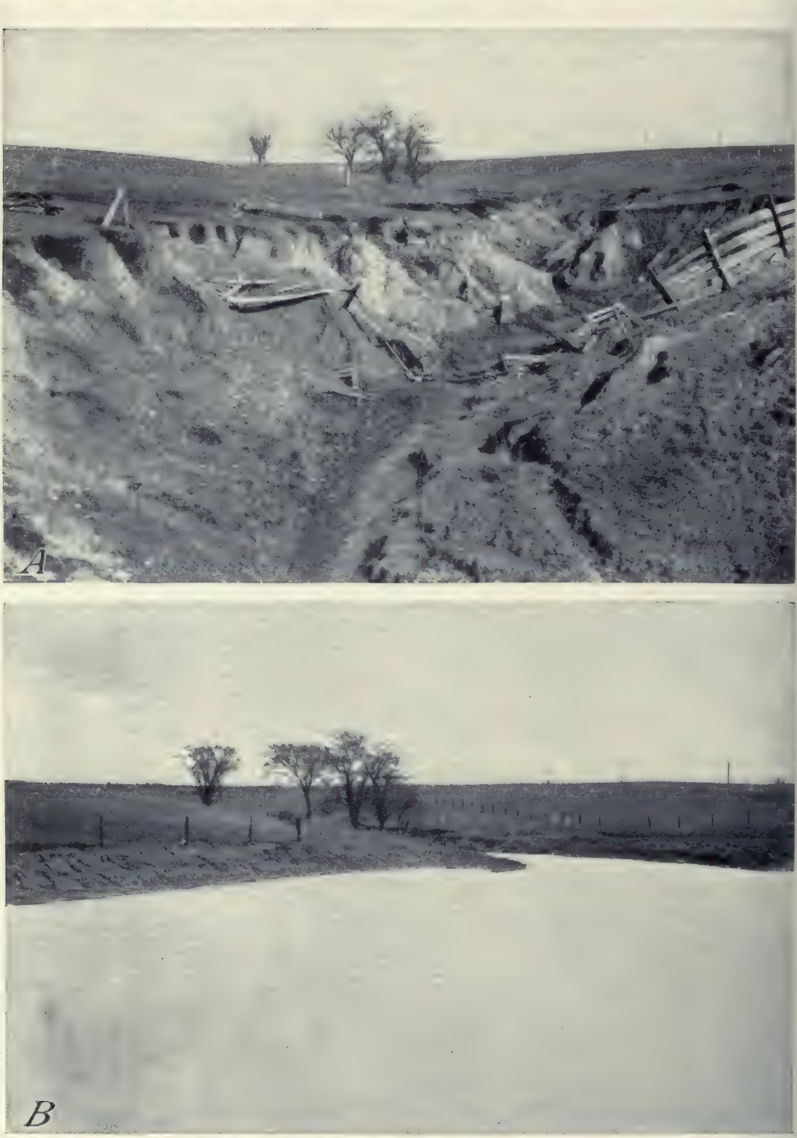


Figure 28.—*A*, An active gully head before control work was undertaken. *B*, The same area 1 year later. An earth dam has impounded the water in the reservoir. Waterfall erosion has been eliminated by making the spillway crest of the dam sufficiently high to prevent destructive action at the gully head.

f a drainage area the entire contributing area above a dam must be onsidered.

Good materials and safe designs are essential for satisfactory ermanent structures. It is impossible to cover adequately in this ulletin the detailed designs required for all the types and sizes of ructures that may be employed to control erosion in gullies. Suit- ble specifications for only the more common types and smaller sizes ave been included.

MASONRY DAMS

Masonry dams are used in areas where good stone is available for asonry work. If only poor rock can be had or if it must be hauled ng distances, concrete structures will be more economical. In the eighborhood of good rock quarries, cut-stone masonry may be heaper than rubble masonry because the latter usually requires ore mortar and the masons spend more time in fitting the rock. 'ith a little care, even inexperienced laborers can make a good asonry dam. Precast blocks, bricks, or tile are frequently used for ese dams. Any rock used should be hard and durable. Figure 9 shows a rubble masonry dam of standard design. In general the inimum dimension for thick- ess of side walls, cut-off walls, d apron should be 12 inches. he thickness of the head wall om the spillway crest to the p of the dam should also be a inimum of 12 inches. Below e spillway crest a slope of ½:1 recommended on the down- ream face. In areas subject severe cold the upstream face the head wall should have a ope of about 1:10 to diminish e thrust, and should be made s smooth as practical. In such reas the apron, cut-off wall, and e wall are often constructed reinforced concrete as added rotection against heaving by ost. An apron length not less an one and one-half times the tal height from the apron oor to the crest of the spillway recommended.

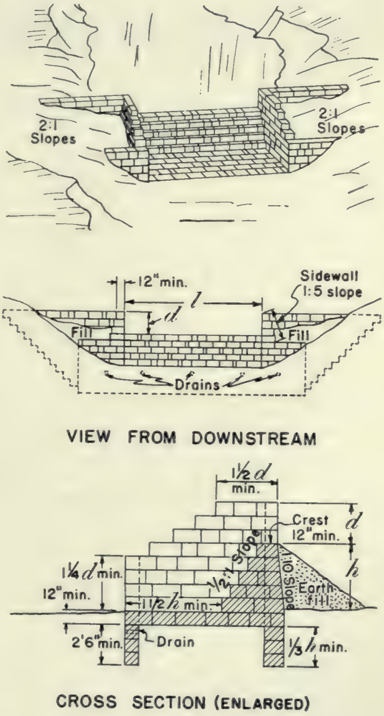


FIGURE 29.—A design for a small rubble masonry dam in which *h* does not exceed 5 feet.

It is important that the cut- ff walls at the heel and toe of e dam be carried at least to e depth indicated in figure 29. he head wall should extend ell into the banks of the gully. a thin head wall has been sed, it is necessary to add but- resses on the downstream side the spillway if the spillway length (l) exceeds 6 feet or if the height (h) exceeds 5 feet. An eart fill should be made against the upstream face of the dam to the heigh of the spillway. A large drainage area or unstable soil condition make it desirable to place riprap below the apron for a distance of to 6 feet. A good quality of mortar of about 1 to 3 mix is suggeste for masonry dams. Table 3 gives the required dimensions of th spillway notch.

CONCRETE DAMS

The use of concrete dams is recommended where there is not adequate material for masonry structures. The same general specifications given for masonry dams can be used for concrete dams. Detaile specifications are indicated in figure 30. A good grade of concret should be used. Informatio about the use of concrete i given in Farmers' Bulletin 1772 Use of Concrete on the Farm It is important that reinforcin steel be used in concrete structures. At least ⅜-inch roun bars, spaced 12 inches center t center both ways, should b used. The specifications indicated in the drawing are fo dams under 5 feet in effectiv height. For structures exceeding 5 feet in height, a specia design is necessary. In cas the spillway length (l) exceed 6 feet, buttresses should be use to brace the head wall. Tabl 3 gives the dimensions of th notch required for the spillway

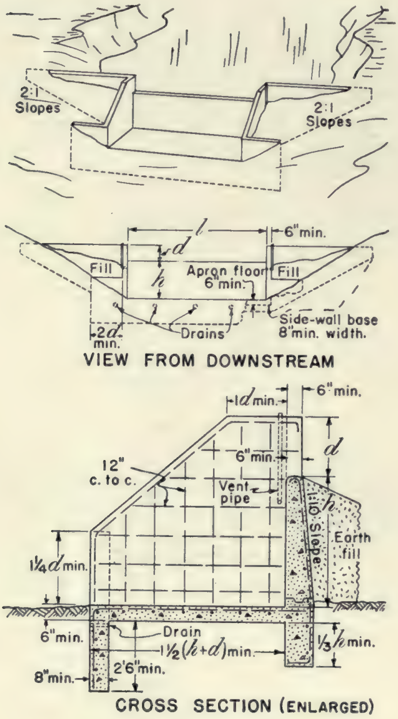

2:1 Slopes
2:1 Slopes
l
6"min.
d
Fill
h
Apron floor 6"min.
Fill
2d min.
Drains
Side-wall base 8"min. width.
VIEW FROM DOWNSTREAM
1d min.
6"min.
12" c. to c.
6"min.
d
Vent pipe
h
1:10 Slope
Earth fill
1¼d min.
6"min.
Drain
1½(h+d)min.
⅓h min.
2'6"min.
8"min.
CROSS SECTION (ENLARGED)

FIGURE 30.—A design for a small concrete dam in which h does not exceed 5 feet.

EARTH DAMS

Earth dams are used in area where suitable locations an material for the fill can be secured and where a permanen structure is desired. Beside being used strictly for gull control, they are also often use for the dual purpose of controlling gullies and providing a roadway across deep gullies; an they may even provide a far reservoir or stock pond if the location is suitable and there is need for th water supply. Two types of earth dams are commonly used to impoun water for farm ponds. In one the excess run-off is carried around th dam by means of a side spillway (fig. 31), and in the other the exces run-off is carried through the dam by a pipe or culvert. If this culver has a vertical intake and a nearly horizontal outlet section the struc ure is commonly called the drop-inlet, soil-saving dam (fig. 32). n many dams it is desirable to use a combination of conduit through he earth fill and side spillway to bypass the excess run-off. Where his combination spillway is used the conduit through the dam is rovided with sufficient capacity to carry only the more common rates

IGURE 31.—An earth dam with a side spillway. The dam and spillway have been fenced to keep out livestock. This stock pond receives drainage from the barnyard, which is not desirable.

f overflow. The side spillway is constructed with its inlet at a slightly igher elevation than that of the conduit and with sufficient capacity o carry the overflow that cannot be carried through the fill during eriods of high run-off. This combination enables the use of cheaper rotection, such as vegetation, for the side spillway, because the pillway will be used only occasionally. Using a side spillway is onsiderably cheaper than carrying all the water through the fill.

The use of side spillways in conjunction with earth dams is limited o locations that have suitable terrain. Usually these spillways are ost applicable to low dams, from which the overflow can be lowered o a stabilized grade below the dam without undue expense. Where rainage areas are small and good sod is available, side spillways overed with grass have been used. Where drainage areas are large nd spillways of durable material are required the drop-inlet type f spillway is frequently the more satisfactory, especially if overfalls re high. This is particularly true in areas where features of the errain discourage the use of side spillways or where the earth fill also to be used as a roadway.

The same general fill specifications ordinarily apply to all types of mall earth dams. The best site for the dam is usually at a narrow eck in the channel, if foundation and spillway conditions are suitble and if the gully floor downstream is on a stable grade. The site hould be stripped of sod and other foreign material and plowed or disked crosswise of the gully. It is desirable to place a core wall i a dam to act as a barrier against seepage, and all pipes or tube through the fill should be provided with ample cut-off collars to prevent seepage. If a pervious foundation (sand, gravel, or shale) i encountered it is usually better to change the location of the dam otherwise considerable expense may be incurred in providing the necessary cut-offs. The earthen fill should be spread in well-packe layers of not over 6 inches each. It should preferably consist of mixture of sandy soil and clay, well compacted, and not too dry

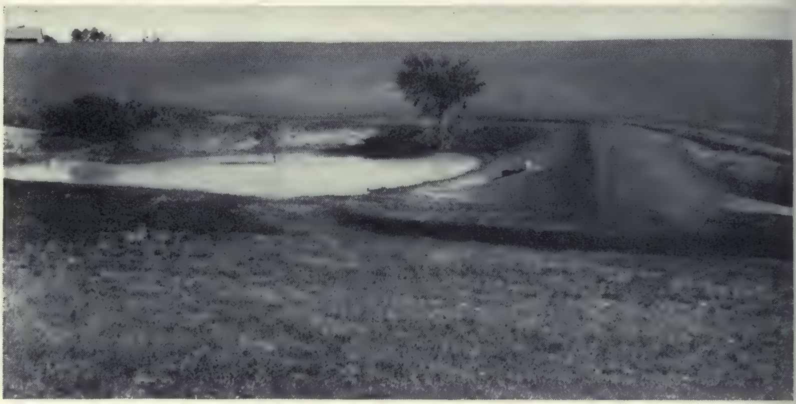


FIGURE 32.—A drop-inlet dam placed in a gully to control further erosion and t reclaim the gullied area above it.

No fill should be made during freezing weather. The side slopes o the settled fill should be not steeper than 2:1 downstream and 3: upstream. For ordinary gully-control work a minimum crown widt of 4 feet is recommended unless the dam is also to serve as a roadwa or reservoir, in which case, top widths of 10 to 20 feet may be require

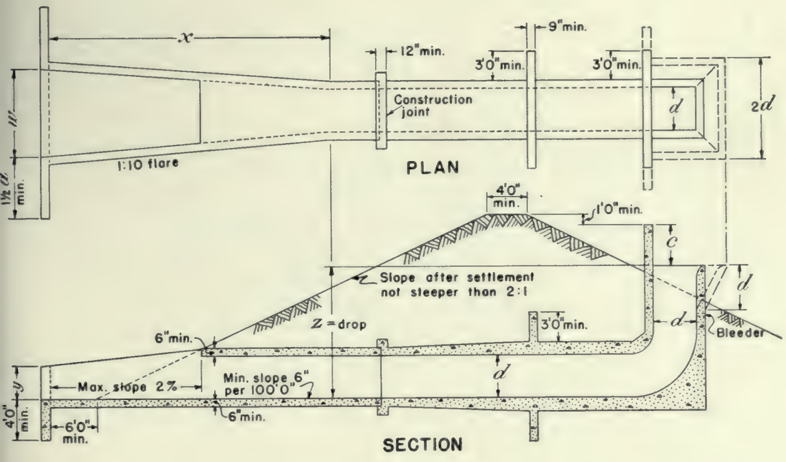
The top of the earth fill should be maintained 2 to 3 feet above th maximum height of flow expected through the spillway in order t provide the necessary protection against overtopping. On larg earth dams a larger margin of safety should be provided. The fi slopes above the water line and the crown should be seeded to grass Advantage should be taken of any natural or artificial vegetated spillway available, if only to the extent of using it as an auxiliary spillwa in the event of heavy run-off.

Figure 33 shows standard specifications for a soil-saving drop inlet dam with concrete barrel and riser (reinforcing steel details no shown). The barrel and at least the lower part of the riser must b built before any fill is made. The barrel should rest on a firm foundation, which can usually be otained if an excavation in firm soil i made for the barrel. After the barrel and riser are in place, the fi can be made. The fill around the barrel and riser must be tampe carefully. If the outside walls of the barrel taper slightly from th bottom to the top, the earth will make a tighter contact with them i settling. It is desirable to locate the barrel as near the center of th gully as possible.

On small or medium-sized drainage areas, tile or corrugated meta ɔes are frequently used for bypassing the overflow through the fill. ɔunded elbow connections between the vertical and horizontal secns of the tube should be used. Concrete culverts less than 2 feet ıare are difficult to construct because of the difficulty of removing ɛ forms; so pipe culverts are recommended for small sizes. Table ɡives culvert sizes recommended in drop-inlet soil-saving dams for rious discharges.

It will be noted that round-culvert dimensions are given in table 4 inside diameter in inches and those for square culverts are given as side width in feet. For example, it is desired to know the culvert e required for a discharge of 250 cubic feet per second to be carried rough a total drop (*z*) of 20 feet; either a 42-inch pipe culvert or a lvert 3½ feet square will carry the discharge. Usually a reinforcedncrete structure will be more durable and is recommended because the high total drop here involved. The choice would thus be a nforced-concrete culvert 3½ feet square.

It is again emphasized that it requires considerable skill to construct drop-inlet dam, and it is therefore safer to engage the services of a mpetent engineer for the construction of at least the larger ructures.



ɡURE 33.—The drop-inlet soil-saving dam with square culvert. The following specifications are recommended: Square culverts should be 2 by 2 feet or arger. If smaller sizes are required, round culverts are used. The outlet width, *w*, should equal the culvert width, *d*, plus 6 feet, except for a culvert 2 eet square, in which case, *w* equals 6 feet. The length *x* of the flared outlet equals the shorter of 10*d* or 30 feet; *c* equals the highest expected flood crest n feet over the inlet lip plus one-half foot.

FLUMES

Flumes (sometimes called chutes) are used to convey run-off down ɛep banks or overfalls to a base grade. The steep slopes on which ımes are usually constructed produce high discharge velocities, and re must be exercised to provide necessary apron and grade protection low the structure. Permanent flumes are usually constructed from

TABLE 4.—*Drop-inlet culvert sizes required for discharges of 25 to 550 cubic feet per second*

Total drop(z) (feet)	Type of culvert	Dimensions [1] of culvert for discharging—																		
		25 cubic feet per second	50 cubic feet per second		100 cubic feet per second		150 cubic feet per second		200 cubic feet per second		250 cubic feet per second		300 cubic feet per second		350 cubic feet per second		400 cubic feet per second	450 cubic feet per second	500 cubic feet per second	550 cubic feet per second
		Inches	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Inches*	*Feet*	*Feet*	*Feet*	*Feet*	*Feet*
5	Round	18	30		36		48													
	Square			2 x 2		3 x 3		3½ x 3½		4 x 4		4½ x 4½		5 x 5		5 x 5	(2)	(2)	(2)	(2)
10	Round	18	24		36		42		48		48									
	Square					2½ x 2½		3 x 3		3½ x 3½		4 x 4		4 x 4		4½ x 4½	4½ x 4½	5 x 5	(2)	(2)
15	Round	15	24		30		36		42		48		48							
	Square					2½ x 2½		3 x 3		3 x 3		3½ x 3½		4 x 4		4 x 4	4½ x 4½	4½ x 4½	5 x 5	5 x 5
20	Round	15	24		30		36		42		42		48							
	Square					2 x 2		2½ x 2½		3 x 3		3½ x 3½		3½ x 3½		4 x 4	4 x 4	4½ x 4½	4½ x 4½	5 x 5
25	Round	15	24		30		36		36		42		48		48					
	Square					2 x 2		2½ x 2½		3 x 3		3 x 3		3½ x 3½		3½ x 3½	4 x 4	4 x 4	4½ x 4½	5 x 5

---

[1] Sizes are for single culverts, inside dimensions. Dimensions of round culverts are given as diameter in inches. Dimensions of square culverts are given in feet.

[2] When culverts larger than 5 by 5 feet are required, twin culverts are recommended.

crete or masonry. Wood or metal flumes have been used, and sod mes (discussed under Vegetation) are commonly used in smaller tersheds. Available material and the degree of permanency deed will determine the most suitable construction material.

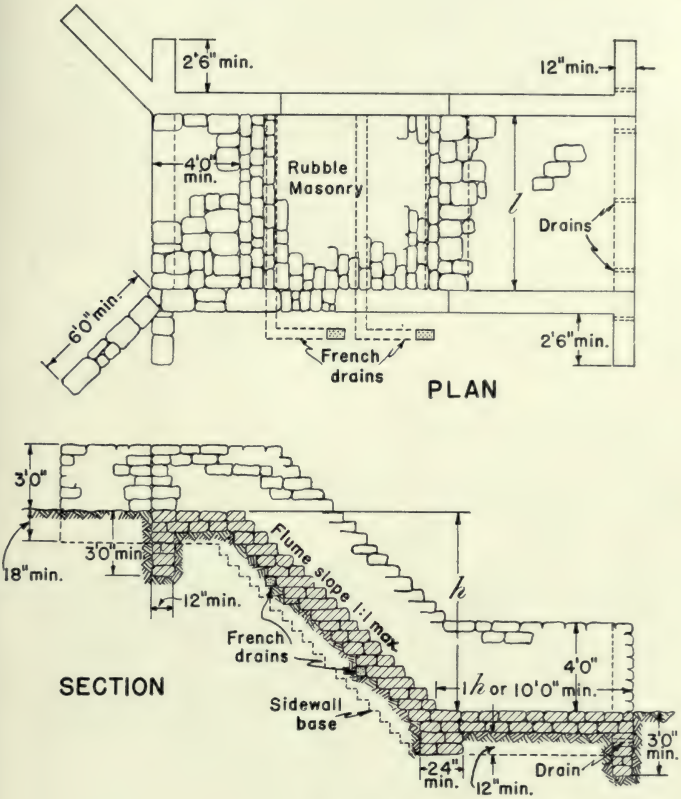

2'6" min.
12" min.
4'0" min.
Rubble Masonry
l
Drains
6'0" min.
French drains
2'6" min.
PLAN
3'0"
18" min.
3'0" min.
12" min.
Flume slope 1:1 max
h
French drains
SECTION
Sidewall base
4'0"
1 h or 10'0" min.
3'0" min.
24" min.
12" min.
Drain

FIGURE 34.—A masonry head flume.

f concrete is used, the slope of the flume should be not steeper than to facilitate pouring. A masonry flume may have a slope as ep as 1:1. Concrete and masonry ordinarily make more desirable mes than wood or metal unless permanency is not essential. Where plicable, sod should be used in preference to any other material cause it is the most economical.

Figure 34 shows a standard masonry head flume and figure 35 a me constructed of concrete. The concrete flume should be reinced with ⅜-inch round steel bars spaced on 9-inch centers both ys. For either structure it is recommended that both the upstream the downstream cut-off walls be dug to a minimum depth of 3 t and that the wing walls extend a minimum of 6 feet into the lead-in es on either side of the flume. Side walls should be high enough to confine completely the maximum flows anticipated during the desig frequency. The length of the apron should not be less than the tota height from spillway crest to apron floor. The gully channel for som distance below the flume should be on a stable grade; otherwise th structure may undermine. A flume is intended to control waterfa

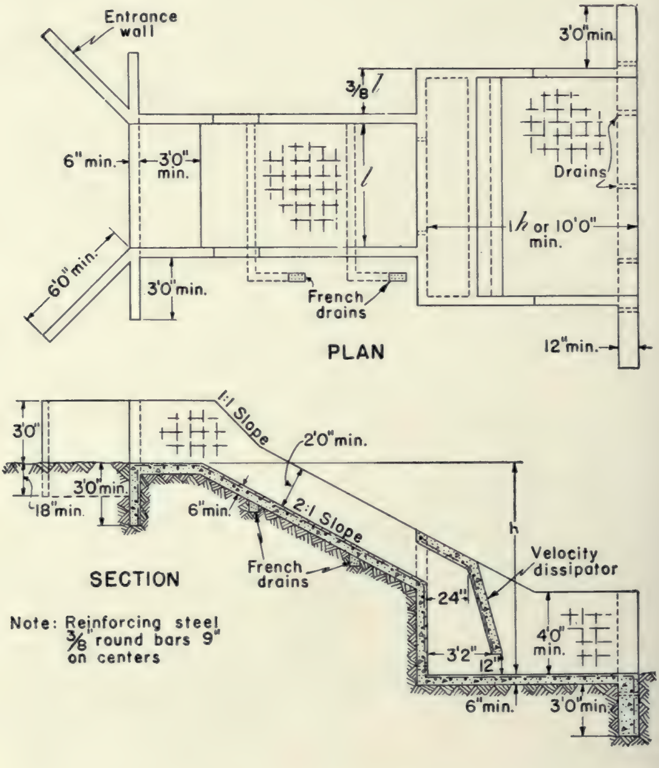

Entrance wall
3'0" min.
3/8 l
6" min.
3'0" min.
l
Drains
h or 10'0" min.
6'0" min.
3'0" min.
French drains
PLAN
12" min.
1:1 Slope
3'0"
2'0" min.
3'0" min.
18" min.
6" min.
2:1 Slope
h
Velocity dissipator
SECTION
French drains
24"
Note: Reinforcing steel 3/8" round bars 9" on centers
3'2"
12"
4'0" min.
6" min.
3'0" min.

Figure 35.—A concrete head flume.

erosion and not channel erosion. In order to assure enough spillwa capacity for the flumes, the length *l* indicated in figures 34 and 35 shoul be a minimum of 1 foot for every 15 cubic feet per second of discharg expected and should have a total length of not less than 4.5 feet.

CULVERT DROP INLETS

Drop-inlet highway culverts are used to combat gully erosion alon highways. Excavation for highway culverts is usually below th natural profile of the ground, and when water flows down the drainage way it has to drop in order to pass through the culvert. This dro sometimes is the beginning of a gully of the waterfall type, which, i ating its way back, may destroy many acres of valuable land on farms djacent to the highway. If conditions below a culvert are unstable, ullies often eat their way slowly up a watercourse toward the highvay and finally undermine the culvert if its substructure is not deep nough to stop further advancement of the gully.

A drop inlet can readily be obtained by constructing a drop box on he upstream end of the existing culvert. The drop box should be uilt to a height sufficient to prevent further recession of the gully and et low enough to allow plenty of freeboard for the highway embanknent. Before a drop inlet is constructed on an existing culvert it is vell to examine the road fill to determine its suitability for the imounding of water. Where it is not desired to impound quantities of vater, the drop inlet may be built in stages by adding height as the ully silts up. Wherever possible in suitable locations it is preferable o construct a regular drop-inlet structure at the time the road is eing built rather than to wait until a gully is formed and then place a rop inlet on an existing culvert. A drop box on an existing culvert fig. 36) will not be as efficient as a hydraulically proportioned barrel nd riser initially placed.

The drop box may be considered as a broad-crested spillway and he required length determined by selecting the length in table 3 for nticipated run-off and flow depth and then increasing this length by ne-fourth. If the entire structure has been designed in accordance vith the recommendations for a drop-inlet dam, the size required for lifferent discharges may be taken from table 4. It is often necessary lso to place protection on the lower end of a culvert in order to prevent gullying. This can be done by using either a suitable drop outlet r by constructing small permanent dams to obtain stabilized grades.

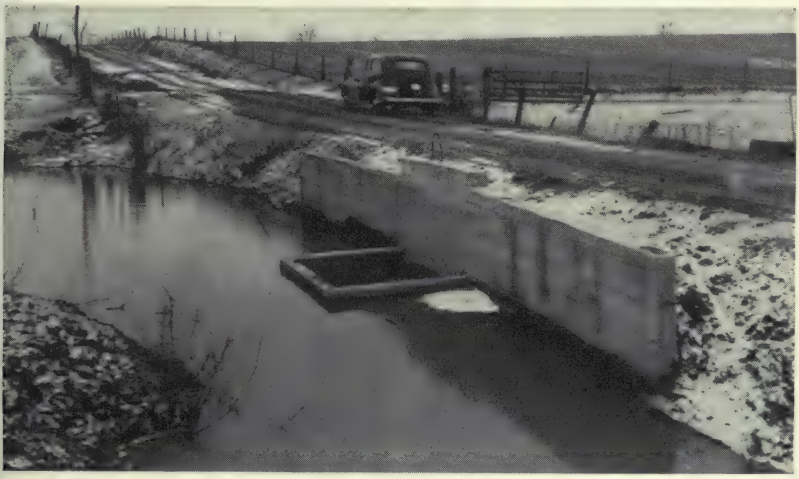


FIGURE 36.—A drop inlet constructed on an existing culvert.

Culvert drop inlets should not be constructed without the approval f the highway officials.

BANK PROTECTION ON SMALL STREAMS

Stream-bank erosion is frequently associated with gully erosion because it is essentially a lateral type of ditch or channel erosion. Gullies often begin at the banks of natural watercourses, especially where the subsurface material is soft and easily worn away, and by waterfall erosion move back into adjacent fields. Portions of valuable bottom lands are frequently damaged by bank cutting that occurs along certain streams, particularly at the bends of winding channels. This cutting may continue even though the stream is on a stable grade. Bank cutting on one side of the stream is usually accompanied by the formation of sand bars or silt deposits on the other, and there is a gradual lateral movement of the main channel. As the process continues, the bends in the channel become more abrupt and the damage to adjacent land more severe.

The numerous factors to be considered and the lack of adequate information makes it impossible to recommend definite control procedure. The success or failure of controlling erosion on stream banks is dependent to a large extent on the judgment of the person in charge. He must have a knowledge of the size of the stream and an appreciation of its destructive force and its flow characteristics. Changing stream flow in one section of the channel will often have a decided adverse effect on the flow for some distance downstream. These resultant effects must be considered, especially when the channel is forced into a new location.

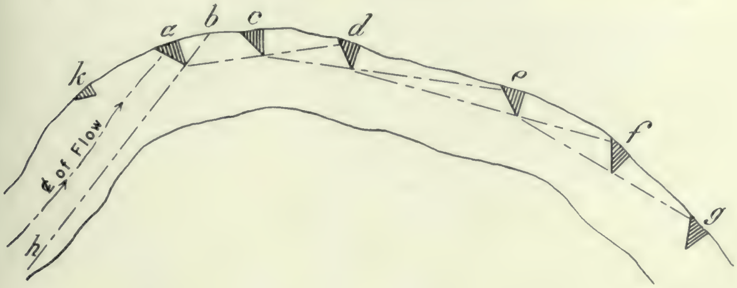
Stream-bank cutting on farms is usually confined to small areas on small streams, some of which flow only intermittently. To control bank cutting on these streams it is generally not necessary to use heavy timber, concrete, or masonry structures, which are ordinarily required for adequate control on large streams and rivers. Suitable trees, shrubs, and grasses are usually sufficient. Before adequate vegetation can be established it is often necessary to use temporary jetties, wing dams, or other obstructions along the eroded bank to check water velocities and start silting. After the bank cutting is checked and sufficient sediment deposited, the necessary vegetation can be planted if sufficient cover is not provided by natural growth.

An important factor in both the prevention and control of stream-bank erosion is the protection of a border strip immediately adjacent to the stream. Instead of plowing to the water's edge or allowing livestock to graze off the protective vegetation, which is found along most stream banks, these areas should be protected. Livestock can be given access to water by lanes fenced to the edge of the stream.

JETTIES AND VEGETATION

If jetties are to be used, the point at which the flow line of the stream intersects the eroding bank is about where the first jetty should be located. Preliminary model tests conducted at the Ohio State University indicated that the intersection point of the eroding bank with a line drawn through the toe of the jetty and parallel to the flow line of the stream should be approximately the midpoint between the first and second jetties. These tests also indicated that the approximate location of each succeeding jetty around the bend would be at a point where a line projected across the toes of the two upper jetties intersects the bank. This procedure of locating jetties is shown in figure 37.

Field observations, as well as the Ohio model tests, indicate that he jetties should point downstream and form about a 45° angle ith the bank. The distance that the jetty should project into the tream will depend on how far it is necessary to divert the flow away rom the eroding bank in order to secure a normal channel condition.



IGURE 37.—Method of determining location of jetties for stream-bank protection: Point *a*, the location of first jetty, is the intersection of the flow line and the eroding bank; jetty *c* is located by drawing the line *hb* parallel to the flow line and across the toe of jetty *a*; *ac* is twice *ab*; jetty *d* is located by projecting a line across the toe of jetties *a* and *c*; the remaining jetties are located in the same manner as jetty *d*; supplementary jetty *k* is located a distance *ac* upstream from jetty *a* and should be approximately one-half regular size.

projection of from one-fourth to one-third the width of the stream t flood flow should not be exceeded. If the jetties are extended too r the undesirable channel restriction produced endangers their ability. The top of the jetty should slope downward toward the ream on about the angle of repose desired for the ultimate bank. has been found advantageous to use low jetties.

The jetties may be constructed of various materials. On shallow, ow-flowing streams, piles of alternate layers of rock and brush have

IGURE 38.—This sausage-type rock jetty is used to protect the stream bank. Note the large amount of material that has been deposited below the retards.

given good results. On faster-flowing streams, the jetties must be well-anchored. Wire-bound, loose rock, which forms a sausage-shaped jetty (fig. 38), has been used extensively. In locations that

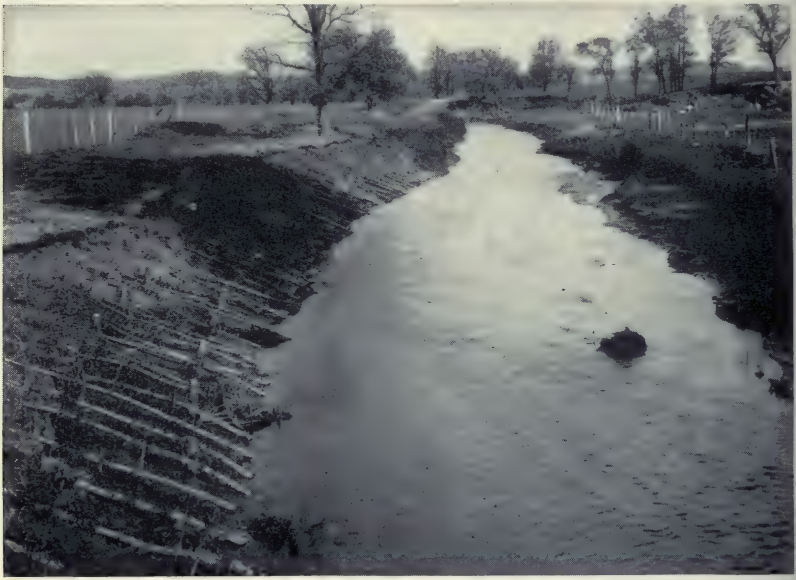


FIGURE 39.—In the spring of 1935 this stream bank was sloped, and willow cuttings were placed along the water's edge. The picture was taken about a year later, at which time additional willow cuttings were placed and anchored with smal poles and wire, as shown.

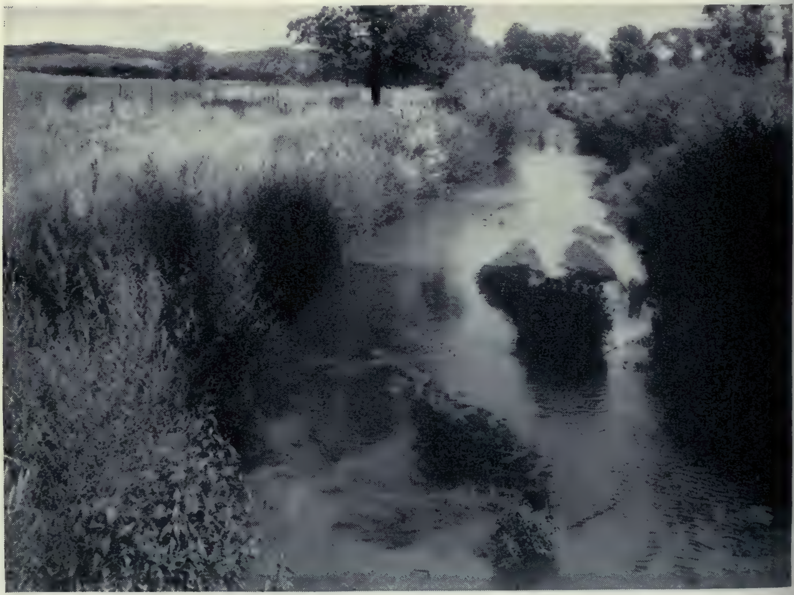


FIGURE 40.—A dense growth of willows on the eroding stream bank shown in figure 39. Photographed July 1937.

equire heavier structures, rock-filled log cribs or timber piling have een used. Crib jetties should be keyed well into the bank and should xtend below the channel bed so as to be protected from undercutting. hose that have undercut at the toe can often be repaired by the use f wire-bound rock.

Willow and cottonwood are desirable trees to plant for stream-ank control. Under certain conditions dogwoods, alder, and other pecies may also be advantageously planted. The entire bank should e planted, and the plantings should extend as close to the water's dge as possible, provided there is 1 to 2 feet of silt or mud above he low-water level in which they can be established (figs. 39 and 40).

CRIBBING OR RIPRAP

The sharper the bank curvature, the closer the jetties should be paced. The curvature may be so great, however, that it will require ore material to construct jetties than to construct revetment or iprap, which would provide a continuous protection. In making the election of the most suitable type of protection one must take into onsideration the material to be used and the most economical emloyment of labor in construction. Where only temporary continuous rotection is desired, brush matting, loose rock that is bound or nchored with wire, and rock-filled timber cribbing have been used. here more permanent protection is desired, stone riprap laid in ement mortar on a slope of about 1:1 may be necessary. Continuous echanical protection should also be supplemented insofar as possible ith vegetation.

CHANNEL STRAIGHTENING

The cost of protecting the eroding banks of a winding stream can ometimes be reduced and necessary protective measures minimized y cutting a new channel across ox bows. Careful preliminary investiations should be undertaken when channel straightening is contemlated. The new channel may induce eddy currents that will aggraate the bank cutting and ultimately lead to conditions even worse han those being treated. Furthermore, channel straightening inreases channel grades and velocities. Sufficient investigations should herefore be made to determine whether the straightening will lead o the development of harmful channel scouring and overfalls. It is nly rarely that it can be justified.

When a new channel is provided it is sometimes necessary to contruct a cut-off structure across the old channel in order to force the tream through the new channel. Full-height structures (average ood stage) should be used, which cut off the old channel entirely by rojecting from bank to bank. A log crib filled with rock or a crib ade of piling and woven wire and filled with rock have been successully used.

MAINTENANCE OF EROSION CONTROLS

An important and frequently neglected practice in the control of ullies is systematic inspection, repair, and maintenance. Too often rosion controls are installed and then neglected until they become o badly damaged that they are no longer effective. When this hapens, practically all expenditures and efforts have been wasted. Intallations for control of gullies should be inspected periodically, especially after heavy rains, to determine whether they are functioning properly or need minor repairs. This is particularly true of vegetative controls during the period when the vegetation is becoming established; at this time it is in its most critical period. The attention given to minor adjustments or repairs during this period often determines whether or not the vegetation will successfully control the gully. Mechanical structures are also more subject to failure when first installed because they do not become thoroughly settled, compacted, or sealed for some time.

It is especially important that all types of erosion controls be protected from livestock (fig. 41). To protect them adequately from damage by grazing and trampling of livestock it is necessary to fence the gullied areas. Hogs particularly should be excluded, for they root up vegetation and damage structures. Vegetation or structures of combustible materials should also be protected from fires. Burrowing rodents occasionally cause failure of structures by digging through or around them.

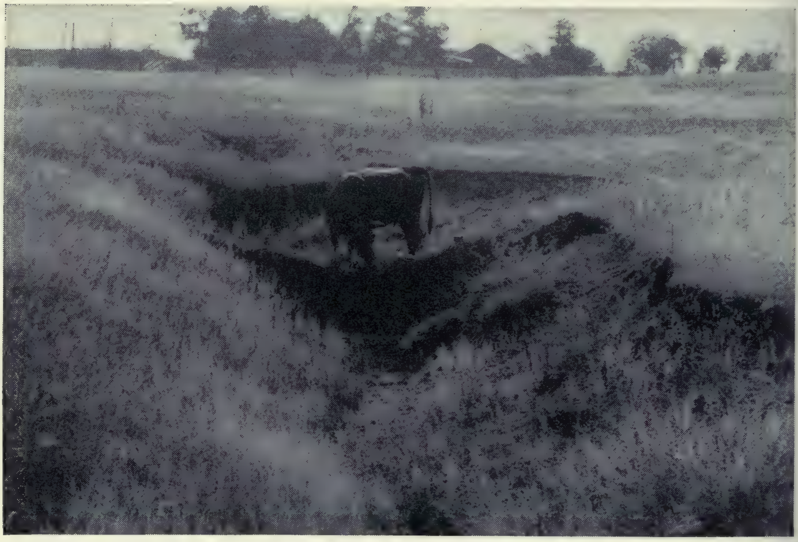


FIGURE 41.—A fence around this gully would have kept the cow out; building a fence is usually less trouble than continually repairing check dams.

Even after erosion controls in gullies have been established, some maintenance is necessary in order to assure proper functioning. Diversion ditches may need occasional cleaning out or rebuilding of damaged sections to renew their capacities. In some gullies, vegetation will require cutting in order that water channels may be maintained to full capacity. Debris that collects in the spillways of structures must also be removed at regular intervals, or it may clog the spillways to such an extent that the structure will be overtopped.

Once a gully has been definitely stabilized, it should be able to carry the normal flow of water without danger of further gullying. There is always the chance, however, that excessive concentrations of flow may cause renewed cutting in the old channel. Gullies that have been stabilized for many years may become active again either because e quantity of water they must carry has been considerably increased because the original erosion controls have failed to function prop-ly. An increase in rate or amount of run-off may result from changes land use, cropping, or tillage practices or from an unusually severe orm.

Failure of erosion controls may thus result from improper applica-on, from lack of maintenance, or from some extreme conditions not dinarily encountered. These factors, potentially capable of dis-pting at any time the stability of the gully, should therefore be arded against to whatever extent is practicable. Any damage curred should be repaired before it leads to further trouble.

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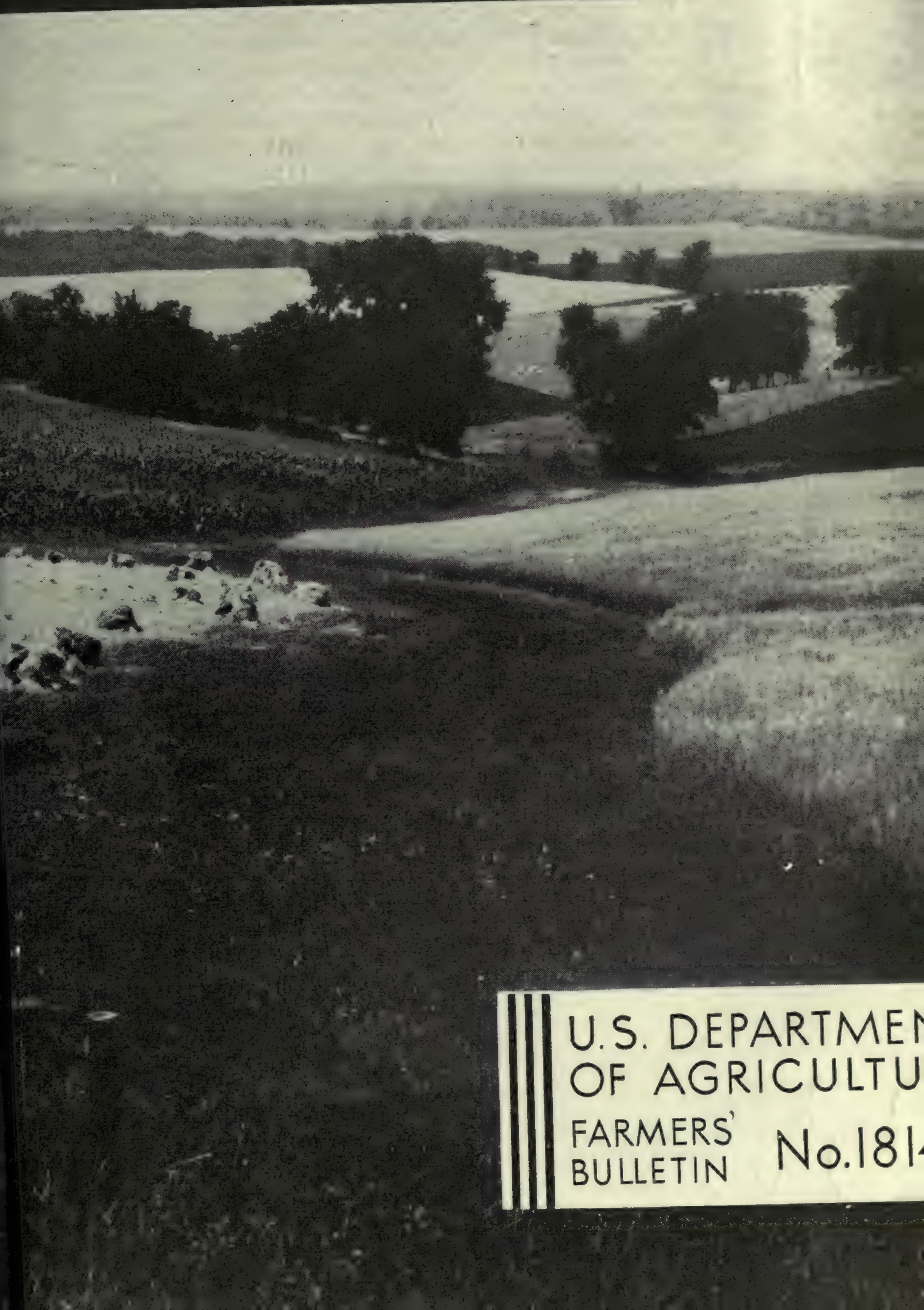

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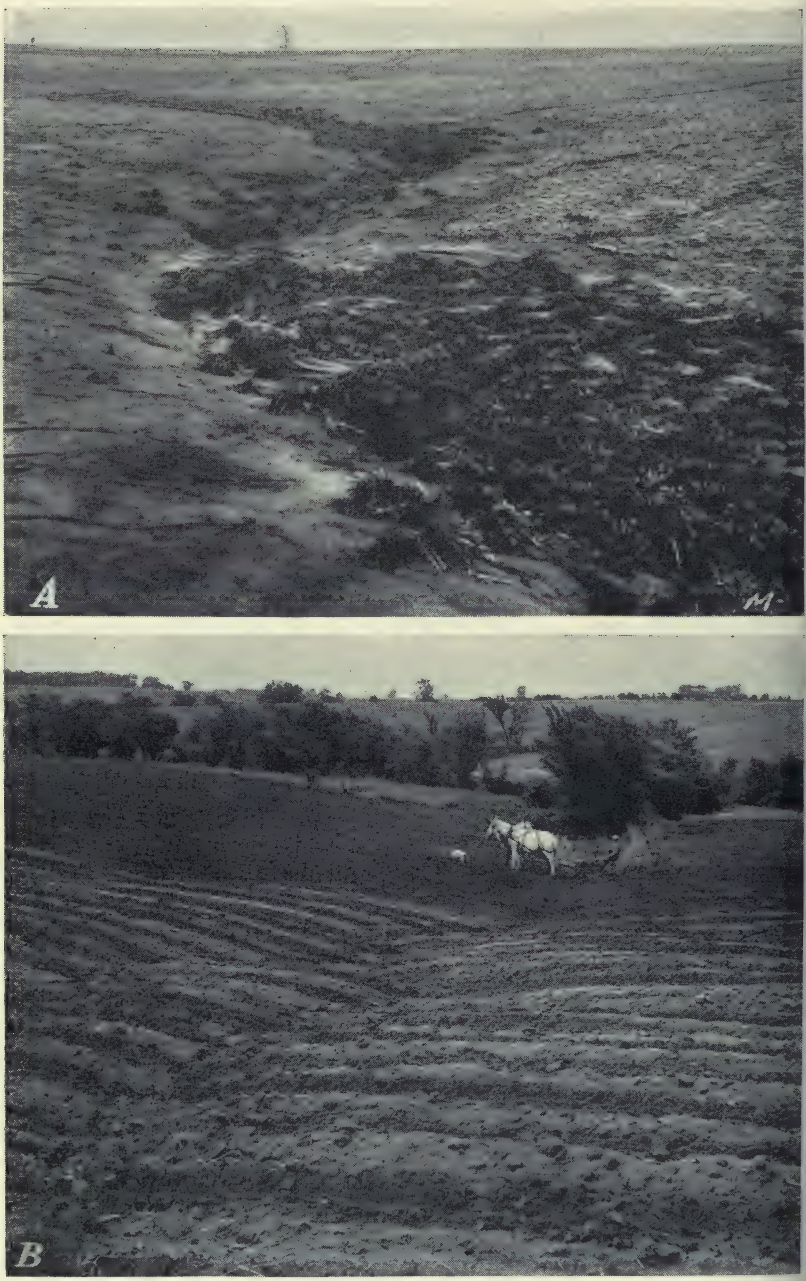


FIGURE 1.—*A*, Faulty tillage practices can be charged with the rapid loss o topsoil from this fertile field. *B*, This natural depression is still a drainageway, even though it has been stripped of its protective plant cover. Withou that cover the drainageway will become a starting point for gullies.

d been left unprotected were unable to carry the concentrated run-
f to stabilized streams or creeks without destructive gullying. Many
ge gullies and ditches were started in these natural depressions
d gradually branched out into all parts of a farm. They marred
e landscape and eventually dissected many fields so completely that
onomical tillage operations were made exceedingly difficult and
any ground-water levels were materially lowered. A large amount
fertile soil was carried away. As the gullying and sheet erosion
ogressed, many of the fields had to be abandoned entirely (fig. 2).
e extensive construction of roads has also greatly changed and
mplicated the pattern of natural drainage and induced widespread
osion.

Terracing to divert run-off from cultivated fields has been used
dely in the South for many years, and the use of terraces is rapidly
reading to other parts of the country. The manner of terrace lay-
t and construction and the lack of adequate outlet protection fre-
ently rendered the earlier work ineffective. Considerable care
d experimentation were often devoted to the construction of the
rraces themselves, but usually little thought was given to the final
sposal of the run-off. The terraces caused increased concentration
run-off, which usually aggravated gully erosion in the drainage-
ays and hastened the formation of objectionable ditches. As the
ainageways gullied, excessive overfalls advanced up the terrace
annels, increasing grades and channel depths until the terraces
came a detriment to rather than a means of conserving the soil.
obably more failures of terrace systems are due to improperly
anned and protected outlets than to any other single cause.

During the last few years the national conservation movement has
d not only to the general recognition of the need for numerous
il and water conservation practices but to an effective coordination
these practices and their application on more farms than ever
fore. One or more such measures as crop rotations, vegetal covers,
rip cropping, contour tillage, diversion ditches, and terracing will
entually become a definite part of conservation practices on a
rge part of our agricultural lands, even though their use will fre-
ently necessitate a radical change in traditional tillage practices.
ese measures will give adequate protection only if proper methods
protecting outlets and drainageways are developed to supplement
em. Soil conservation measures can give only temporary or partial
otection if the drainageways are neglected and allowed to erode.
rracing, in particular, will never be satisfactory unless the terraces
npty into properly constructed outlets. In order to provide for
e safe disposal of surface run-off, stabilized drainageways will be
cessary even in areas where terracing is not used. In fact, the
tablishment of satisfactory drainageways is one of the initial prob-
ms in developing soil conservation plans in all areas where there
surface run-off.

Under the Soil Conservation Act of 1935 the Government has
tablished numerous demonstrational and experimental projects in
fferent problem areas of the United States. These projects have
ovided opportunity for intensive study in establishing practical

water-disposal systems on cultivated land and have been an impetus to such study. They have provided an opportunity for extensive field observations and trials and for men with special training in engineering, soils, and agronomy to work together on the same problem From the extensive field operations of these specialists has come a material advancement in the technique of constructing satisfactory outlets and drainageways. During the earlier part of this work more information was obtained on the design and construction of mechanically protected outlets than on the use of vegetation in run-off disposal. Although mechanically protected outlets were effective and many of them justifiable, the need for a more simple, cheaper, and more practical means of controlling erosion in outlets and drainageways was soon recognized. Recent observations indicate that sod can be used extensively as a protective covering or lining for constructed channels and drainageways in the majority of agricultural areas. When properly used, its resistance to erosion from concentrated flowing waters is much greater than was at first believed.

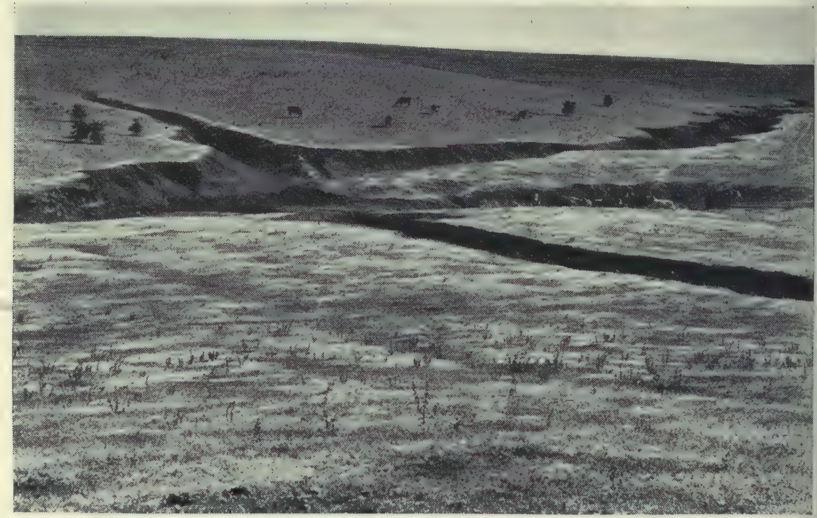


FIGURE 2.—Severe gullying eventually branches out from drainageways that are inadequately protected. This field can no longer be economically tilled.

TYPES OF DRAINAGEWAYS AND OUTLETS

The classification of drainageways and outlets used in this bulletin is shown in table 1. Natural and constructed drainageways are used on both terraced and unterraced areas. On terraced areas there are two main types of outlets, individual outlets and collective outlets. Terraces have individual outlets if the run-off from each terrace is independently discharged over a slope. A collective outlet is a draw or channel that receives the discharge from two or more terraces. A collective outlet is referred to as an outlet strip or a terrace-outlet channel.

TABLE 1.—*Types of drainageways and outlets*

Drainageways	Natural		Constructed		
	With plant cover	Without plant cover	Vegetated	Mechanical	Miscellaneous
raws (unterraced areas).	Grassed [1]	Rock	Meadow strip	Drop check	Combination.
	Wooded		Pasture strip	Lined [2]	Unlined.
ndividual outlets	Grassed slope [1]	Rock slope	Grassed slope [1]	Drop check	Absorptive.
	Wooded slope		Wooded slope	Lined [2]	Accumulative.
ollective outlets	Grassed [1]	Rock	Meadow or pasture strip.	Drop check	Combination.
	Wooded		Field or roadside channel.	Lined [2]	Unlined.

[1] Often referred to as "meadow" or "pasture," depending on how the forage is utilized.

[2] Discharge velocities are usually higher in lined outlets, and the channels are sometimes referred to as igh-velocity channels.

NATURAL

A few farmers were farsighted enough when they first plowed new ields to leave the original plant cover undisturbed in natural depresions, the carriers of run-off from their fields (fig. 3). These farmers have invariably been well repaid because the original cover of egetation has prevented gullying and made unnecessary costly xpenditures to reestablish a protective covering. These few undisurbed draws are now the only drainageways still protected by their riginal vegetal cover. They should be protected and utilized to the fullest extent possible because it is usually difficult to reestablish or uplicate the native vegetation, and, at best, it is likely to be a costly rocedure.

Natural drainageways may also include some rocky slopes or draws hat convey run-off and are adequately protected from erosion by ock or gravel deposits. These are often referred to as rock washes.

IGURE 3.—This bluegrass drainageway near McGregor, Iowa, has not been plowed in the last 35 years. It is typical of some of the well-maintained drainageways in this locality.

Natural drainageways that have been only partially damaged by overgrazing or the development of small gullies or breaks in the original cover can usually be repaired and restored. The sooner this is done the more successful it will be and the smaller will be the expenditure of labor and materials required. Frequently the plant cover can be revived by only restricting grazing on the area for one or more seasons. In addition to protection from overgrazing, the more severely damaged areas may require fertilization and the reestablishment of vegetation on certain portions by seeding or sodding. It is usually much easier to repair a few weak patches or damaged spots in a drainageway in which the major portion is still covered with the natural vegetation than to establish a new vegetal cover over the entire area. Once a complete cover has been restored, it should be protected from future damage. Well-protected natural drainageways usually prove to be the most satisfactory.

CONSTRUCTED

Since so many of the natural drainageways have been severely damaged by gullying or have had their protective covering completely destroyed, it is necessary either to construct new ones or to rebuild old ones in order to provide adequate means for the safe disposal of rainfall that cannot be economically utilized on the watershed. The reconstruction of these drainageways is usually most satisfactory if the natural features of the drainageway are reproduced as nearly as possible. There are some areas, however, where the soil and climate or the artificial conditions introduced with agricultural practices may justify or even necessitate some modification of nature's procedure. Constructed drainageways and outlets now in use can be classified in the three groups indicated in table 1: (1) Vegetated, (2) mechanical, and (3) miscellaneous.

Vegetated drainageways and outlets are those in which some form of vegetation, usually some dense-growing grass, is established to protect the soil from erosion. Several types have been developed in order to provide for the variations in local conditions and topography. If a natural swale or depression is retired to permanent vegetation for the purpose of conveying run-off from either a terraced or unterraced area, it is referred to as a meadow or pasture strip, according to the use made of the forage (fig. 4). If used for hay production, it is a meadow strip; if it is to be grazed, it is a pasture strip. Slopes may be vegetated and used for individual terrace outlets. Restricted vegetated channels are frequently used as collective terrace outlets. They differ from grassed strips in that the formed or restricted channel concentrates the run-off on a narrower area (fig. 5). They may be located either in fields (field channels) or along the highway right-of-way (roadside channels), where they usually serve a dual purpose by conveying the run-off from the highway as well as from the adjacent land. Because the cross section of constructed channels is smaller than that of the meadow or pasture strips, the velocity and depth of flow in these channels is greater, and therefore more precaution is necessary in

GURE 4.—A meadow-strip drainageway that gives satisfactory run-off disposal. The hay crop grown on this drainageway provides an income from the and.

GURE 5.—V-shaped vegetated channels such as this are sometimes used where a satisfactory plant cover can be provided, where the run-off is small, and where it is desirable to concentrate the discharge on a restricted area.

their design and construction. The channel cross sections are limited to those that it is practical to construct, vegetate, and maintain. Where one channel will not provide adequate capacity, multiple channels, which consist of two or more parallel channels, may be used.

Mechanical protection is usually used only in outlets where climate and soil conditions restrict the development of an adequate protection of vegetation. Where unusual conditions prevail, mechanical protection may even be necessary in drainageways on unterraced areas as well as in outlets on terraced areas. Structural protection such as masonry, asphalt, or metal drop checks or linings are used to prevent advancement of overfalls and channel erosion. Low-velocity mechanical outlets are built by using a series of drop-check structures at definite intervals to reduce the channel grade (fig. 6). The flat grades between structures prevent the run-off water from attaining a scouring velocity. If considerable run-off must be conveyed over steep slopes it is sometimes necessary to provide a continuous channel lining of an erosion-resistant material such as masonry, asphalt, or metal. The steeply sloping conduits require minimum cross-sectional areas, and they produce high channel velocities, but the structural linings prevent harmful scouring (fig. 7). These conduits may be of the open type, placed at the ground surface, or of the

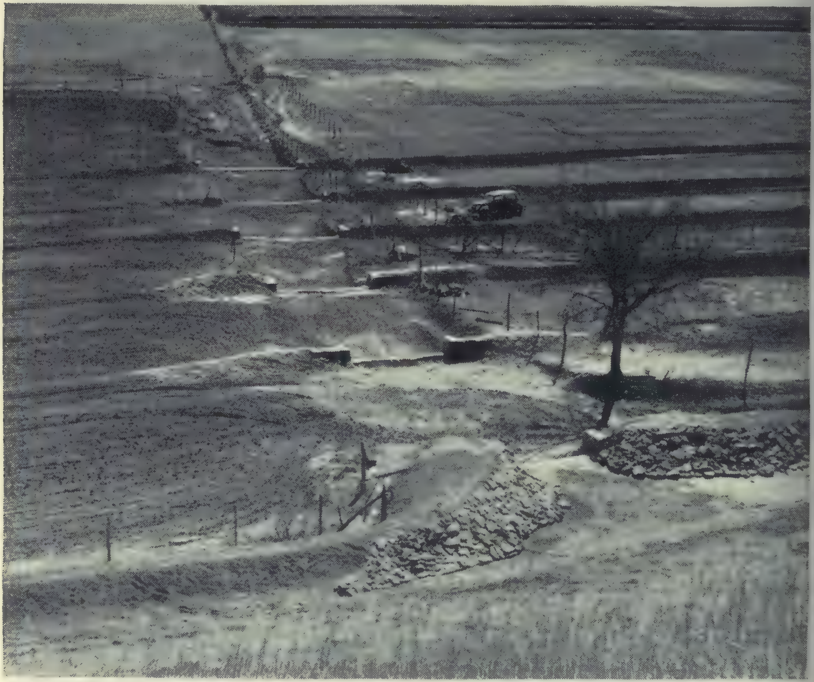
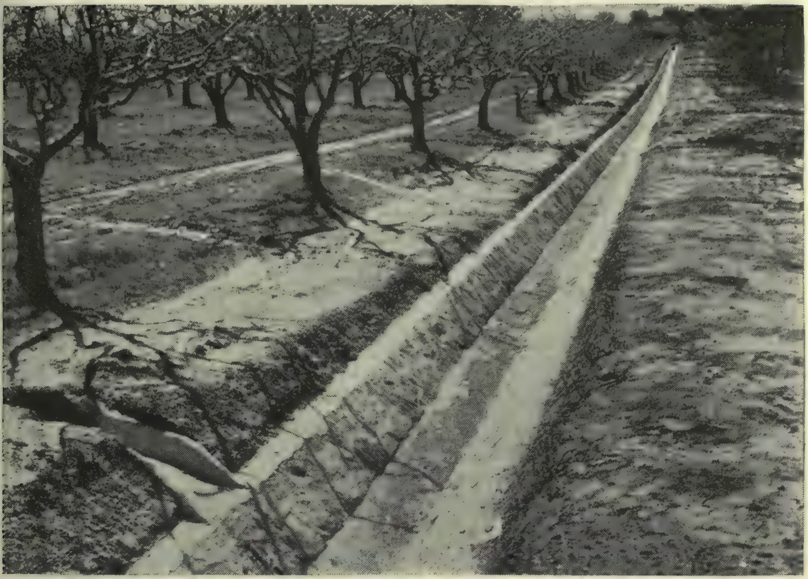


FIGURE 6.—Drop-check structures reduce the grade of this terrace-outlet channel. The run-off is slowed down.



IGURE 7.—This outlet channel is protected by a continuous lining of rubble masonry.

osed type, which is usually placed under the surface. Considerable recision and care must be exercised in the use, design, and con-ruction of mechanically protected outlets.

Numerous miscellaneous types of drainageways have been used tisfactorily in various sections of the country. Their use, however, almost entirely dependent upon certain local conditions. Where at slopes prevail, unlined or unprotected drainageways are often tisfactory. In combination outlet channels more than one type of rotective measure is used to provide satisfactory run-off disposal. the combination consists of vegetation and mechanical structures e vegetation is usually used in the upper reaches of the channel and e mechanical measures in the lower portions. Absorptive outlets e those in which contour furrows, ridges, ditches, or other such eans are used to collect and hold the run-off until it is absorbed the soil. In limestone areas it is sometimes possible to dispose of n-off from terraced fields or other land by directing it into sink-oles, which are common in these areas. Run-off may also be dis-arged directly into farm ponds, dugouts, or similar reservoirs and ored for recreation or for use by livestock or wildlife.

PLANNING RUN-OFF-DISPOSAL SYSTEMS

The success of conservation measures is dependent upon satisfactory rainageways. In the reorganization of farm plans for the estab-shment of proper land use and soil conservation measures the lanning of these drainageways should usually be considered first.

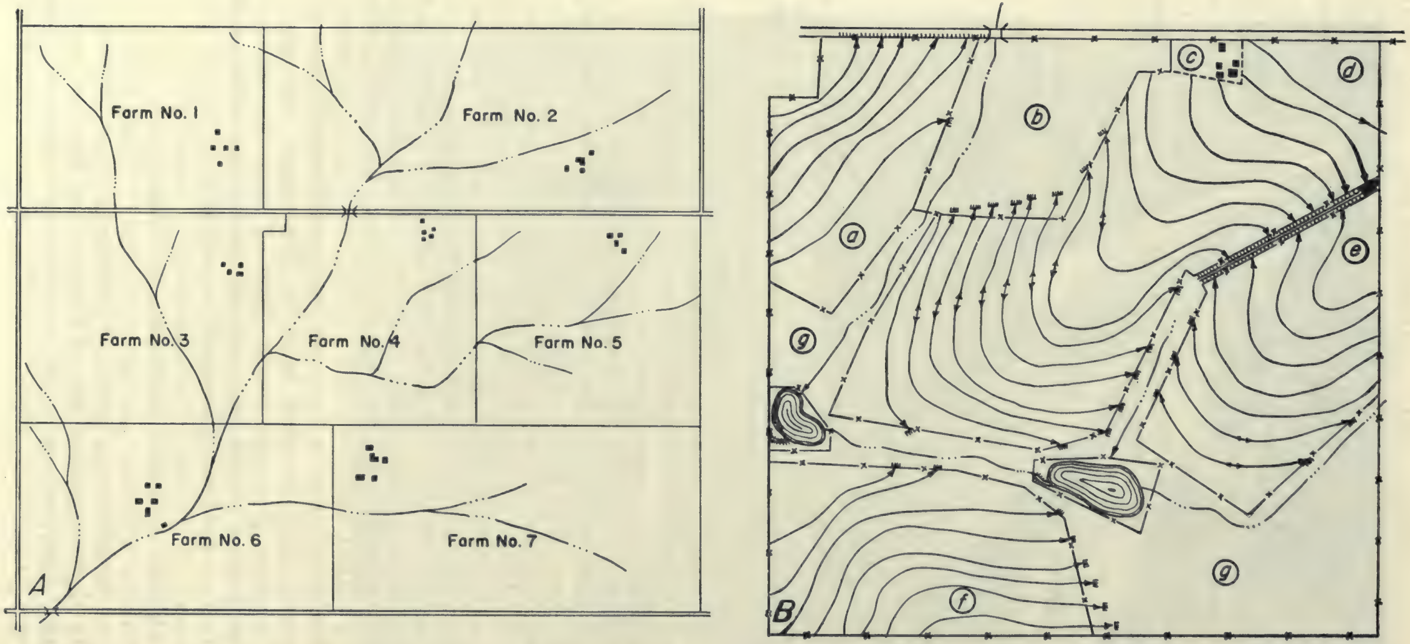


FIGURE 8.—*A*, The natural drainage depressions for this group of adjoining farms illustrate why it is frequently necessary to plan a surface-drainage system for any individual farm in conjunction with that of one or more adjacent farms. *B*, A water-disposal plan for farm No. 4, shown in *A*. The arrows on the terrace lines indicate the direction in which the terraces drain. On fields *a*, *d*, *e*, and *f* crop rotations, contour tillage, terracing, and strip cropping are practiced. Field *b* is in woods, and field *g* is in pasture. The pasture has been extended to include two farm ponds and the drainageways that carry run-off from fields *a*, *b*, *d*, *e*, and *f*. Part of the terraces on field *a* discharge into a roadside outlet channel cooperatively constructed and maintained. The upper part of the drainageway between fields *d* and *e* is a sodded channel and carries run-off from the adjoining farm.

djusting field boundary lines, terracing, strip cropping, and other nservation measures are often necessary to assure the most satisfctory drainageways. It would be poor planning to expend money nd effort on contour cultivation, conservation rotations, strip opping, or terraces and to neglect the drainageways. Gullying in ainageways would eventually destroy any benefits derived from the nservation measures on the adjacent slopes. Run-off-disposal sysms can seldom be eliminated because considerable surplus rainfall ill generally be discharged from all agricultural land, regardless the soil and water conservation measures used. In semiarid gions, where absorptive measures can be used to retain most of the infall, there is less need for drainageways.

The importance of developing on a farm a run-off-disposal plan at is in harmony with drainage plans on adjacent farms or fields is ident when it is realized that run-off discharged from one area ually passes over adjacent areas before it reaches a regular waterurse. Natural depressions generally provide the most satisfactory ainageways. Attempts to establish new ones in other locations to commodate individual plans or conservation practices frequently ad to serious difficulties. If a complete water-disposal plan is not ade at the outset, a series of unrelated outlets and drainageways is equently developed. They may follow farm roads, field or property es, or other similar features that have no definite relation to natural ainage courses. Many of these individual drainageways that sult from haphazard planning cannot be utilized efficiently when ditional conservation measures are established, and they may even nder the use of subsequent conservation practices.

It is usually necessary to plan surface drainage systems according drainage units. A drainage unit comprises a natural depression drainageway, together with the adjacent land that slopes toward Since farm boundary lines seldom coincide with natural draine divides, it is frequently necessary to consider the fields on adjacent rms in developing preliminary drainageway plans for a single farm. gure 8 shows that natural drainageways may cross several farms such a way that run-off disposal must be planned for individual rms in accordance with the natural drainage of adjacent farms. ith a properly planned procedure, individual drainageways can ually be established so that all the drainageways on a single farm on adjacent farms can be fitted together without difficulty or pense when the final job is completed for the entire drainage unit.

The first step in planning any type of run-off-disposal system for a ld or farm is to make a physical inspection of the adjacent areas as ell as the area under consideration and note topographical features ch as drains, laterals, ridges, slopes, and gullies and any other features at may influence the location of drainageways. Field and property es, roads, buildings, and fences should be noted. This preliminary spection will make possible a tentative selection of at least the main pressions that should be reserved for permanent drainageways. The mber of lateral drainageways required will depend not only on the pographical features but also on the soil conservation practices used. here run-off interception is to be provided by the use of such means

as terraces and diversion ditches the run-off is usually diverted fron
one or more minor depressions, so that the number of drainageway
that must be constructed is materially reduced. As land use and soi
conservation plans are developed for the farm, the field boundarie
fence lines, and meadow or pasture areas can often be changed so a
to make it easier to establish and maintain the selected drainageway
For example, pasture and meadow areas can often be arranged to in
clude the main drainageways. If this is done, it is easy to utilize th
grass on the drainageways and to maintain them. The vegetation i
the pasture or meadow can be extended across the drainageways, an
the subsequent grazing and mowing will usually take care of the prin
cipal part of the maintenance.

UNTERRACED AREAS

On unterraced areas used for the production of farm crops it i
usually best to use wide grassed drainageways for carrying the run
off over slopes that are steep enough to produce erosive velocitie
Plans should provide for continuous protection of the main depres
sions from field to field and from farm to farm until a stabilized water
course is reached. If continuous protection is not provided, overfall
usually develop and undermine parts of drainageways that may other
wise be adequately protected. Sloping lateral depressions that carry
considerable amount of run-off must also be protected. Where a larg
enough area of land cannot be retained economically for a grasse
drainageway, where an adequate plant cover cannot be established, o
where large amounts of run-off must be carried, it may be necessar
to use partial or even complete structural protection in drainageway
However, this type of protection is usually not necessary and, excep
for special conditions, cannot be economically justified. On highl
developed orchard lands or other high-income crop areas structura
protection may be justified.

The difficulty of establishing adequate grass covers and the cost o
the land that must be retained for run-off disposal discourage th
extensive use of vegetated drainageways.

It is sometimes more difficult to provide practical protection fo
drainageways on cultivated areas where no run-off-diversion meas
ures are used than on terraced areas. In areas that have rolling relie
the upper reaches of watersheds branch out into numerous natura
depressions, each of which carries run-off to the main drainageway
Where these depressions are comparatively close together and ar
adequately protected they may form numerous grassed strips tha
dissect a field to such an extent as to prevent economical tillage opera
tions (fig. 9). This condition will favor retirement of the entir
field to a permanent cover or the use of applicable run-off-diversio
measures that eliminate some of the vegetated drainageways an
thus facilitate economical tillage practices. A field divided in thi
way is particularly troublesome where large tillage machinery i
used. On land that is to be retired to a permanent plant cover th
planning of a satisfactory run-off-disposal system is comparativel
simple, because each natural depression can serve as a natural drain

geway after the cover is established. Establishing a satisfactory ver will usually prove to be a more difficult problem.

GURE 9.—In cultivated fields that have rolling relief such as this it is sometimes difficult to provide adequate protection in all natural depressions without seriously interfering with economical tillage operations. Terracing or retirement of the entire area to permanent cover may be advisable.

TERRACED AREAS

The problem of locating and establishing outlets is inseparably sociated with planning the terrace system. The cost of terrace conruction and the success of the terraces are dependent upon the oper planning of outlets. Adjustments in the location and in the rection of the flow of terraces will often greatly simplify outlet ntrol. A slight variation of the location of the first terrace or change in the vertical interval on subsequent terraces may make it ssible to discharge the run-off from the terrace at a point where tlet protection is comparatively simple. Changing the direction the terrace grade near the center of a terrace or running the ade of alternate terraces in opposite directions will diminish the ncentration of run-off and often make it possible to distribute the n-off from a terraced field over native cover on adjoining areas. here special outlet strips or channels are required, it is often more tisfactory to drain terraces toward the outlet channels from both des so that each outlet channel will serve a larger area. Such an rangement reduces the number of channels needed. As a general le all collective terrace outlets should be as straight as it is practical make them, and they should be planned so as to provide continus protection from the uppermost terrace on the slope down to abilized watercourses. If run-off is discharged from areas higher the slope than the terraces it is usually necessary to develop the rrace-outlet system so as to carry this additional run-off.

Terrace outlets should be located where they can be constructe and maintained most economically and where they will functio satisfactorily. Preference should be given to the natural depression or more gentle slopes and to field or property lines, where the outle channels will give minimum interference with tillage practice Other topographic features that must be considered in determinin the location of outlets are the size of fields, as it affects the drainag area at the outlets, and the grade and stability of natural drainage ways below the outlets. Unprotected road ditches and large o crooked gullies should seldom be used to dispose of terrace run-o because it is difficult and expensive to protect and maintain them Run-off should usually be diverted from such locations. Howeve properly constructed and protected highway ditches can often be use to advantage for the disposal of run-off from terraces. It has sometimes been found desirable for the landowner and highway officia to make a definite agreement to develop a joint outlet channel tha will serve the dual purpose of draining the farm terraces and th adjoining highway (fig. 10). It may often be advantageous for tw

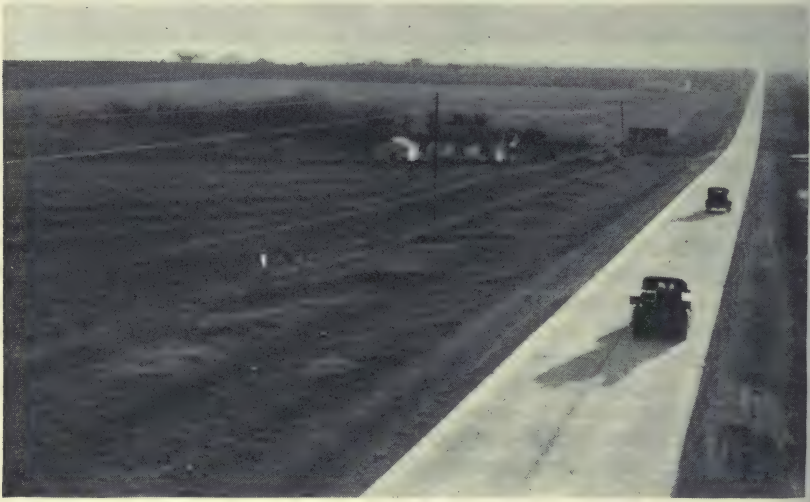


FIGURE 10.—A cooperatively constructed and maintained terrace-outlet channe and highway-drainage ditch. If a satisfactory agreement can be arrange between the landowner and highway officials the same ditch may be used t carry the run-off from both the highway and the adjacent farm land.

or more landowners having terraced fields in the same drainage uni to plan a joint outlet system, provided they can make a satisfactor agreement for joint construction and maintenance of the terraces an outlets. The importance of satisfactory preliminary plans for bot terraces and outlets lies in the fact that terraces, when once constructed, are permanent unless they are improperly maintained Their relocation is costly and difficult. Furthermore, improperl located and improperly protected outlets may cause the cost of outle construction to exceed the construction costs of the terraces them-

ves, and this makes the final cost so great that it discourages ter-
ing where it is needed for adequate soil conservation.

t must be recognized that the problem of terrace-outlet protection
neither equal in importance nor uniform in character in the vari-
climatic, geographic, soil, and type-of-farming regions. Some
ieties of grasses and methods of establishment are well adapted
certain localities but are impractical in others. The local rainfall
ensities, the distribution of the rainfall, and the season of the year
which terrace-outlet construction is undertaken will have a marked
luence in determining the most satisfactory procedure. Where
ounts of run-off are large, or where high land values prevail, cer-
n more expensive types of outlets may be justified. Because of
diversity of conditions it is obviously impossible to select a
ndard method of outlet control and attempt to apply it universally.
satisfactory procedure is to determine in what order the various
es of outlets should be considered and what form of each type is
t adapted locally and can be economically established or con-
ucted.

rom the standpoints of economy and practicability, including
e of establishment on the average farm, the various types of ter-
e outlets should be considered in the following order: (1) Grassed
wooded individual outlets; (2) meadow or pasture outlet strips;
grassed channels; (4) mechanically protected channels.

n field practice natural conditions often prohibit the use of certain
these types, but they should usually be given consideration in the
ler named and no method discarded as impractical until thorough
estigation has proved it to be so.

The simplest and most economical type of outlet is usually secured
erraces can be discharged directly onto well-established sod or other
nt cover that will provide sufficient protection for the additional
-off from the terraces. Good pasture or meadow sods usually give
safest protection. An unburned and ungrazed woodland on rela-
ely flat slopes may sometimes be satisfactorily used if necessary.
nsiderable precaution must be taken in the selection of the wooded
pe and in the manner in which the concentrated run-off is dis-
rged into the woods. Usually steep wooded slopes should not be
d. Poorly sodded areas, grazed woods, or fields retired from culti-
ion to pasture or meadow can often be utilized for individual out-
s, provided the necessary measures are applied to rejuvenate or re-
ablish a good plant cover before it must carry the additional run-off
m terraces. Individual outlets (fig. 11) will usually be most ap-
cable in areas of rolling relief where cultivated fields are small to
dium in size and where a considerable proportion of the farm land
etained for pasture and meadow.

f a collective-type outlet is necessary, turning natural depressions
o meadow- or pasture-strip outlets and drainageways not only pro-
les a practical method of disposing of the run-off but also makes
ective use of areas that otherwise would often be unproductive. The
adow or pasture strip is a simple type of outlet that fits in with
ctices on farms where there is need for pasture or hay; and many
h outlets now in use have proved to be the most profitable areas on

the farm. The convenience of using drainageways for hay productic however, should not be used as a justification for not including h crops in the rotations on adjacent fields when their use is necessa to provide effective conservation. Natural meadow and pasture stri already exist in some areas, and in others where there is a suital depression this type of outlet can often be developed satisfactorily a relatively low cost.

Where the slope does not exceed 5 to 6 percent, a wide, shall depression is preferable, and the terraced fields should be located

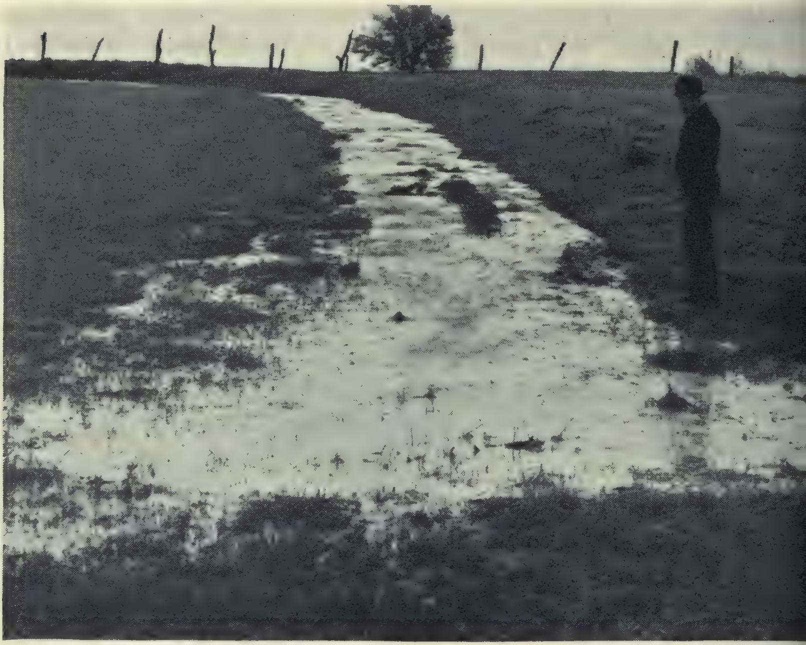


FIGURE 11.—Run-off is here discharging from an individual terrace over well-sodded slope. The outlet end should be located and shaped so as spread the discharge in as thin a sheet as possible over the slope.

that the terraces can be discharged directly into the grassed stri The presence of a few small gullies in the depression does not nec sarily prohibit its development into a satisfactory strip outlet becau usually the small gullies can be graded or plowed in and the necessa vegetation established.

In localities where good turf can be established but conditions pr hibit the conversion of sufficiently large areas to meadow, pasture, wide grassed drainageways, a more restricted type of channel c be used. These outlet channels, designed to carry the discharge fro the terraces at a higher velocity, do not require for a given amou of run-off a cross-sectional area as great as that in the meadow pasture strip. Their success is dependent upon the establishment a turf that will withstand comparatively high run-off velociti without harmful scouring. Their cross sections must be propo ned to provide ample capacity, facilitate proper maintenance, and strict the maximum channel velocity to that which the turf will rry safely. Usually the maximum velocity in channel-type out- s is from three to four times greater than in wide strip-type drain- eways, and the width of the area required can frequently be duced to as much as one-tenth that commonly used for the wider ainageways.

If all types of outlets protected by vegetation are found to be in- equate or impractical, mechanical outlets are usually considered. eir use will ordinarily be restricted to areas where climatic and il conditions or high land values prevent the development of onomical vegetated outlets or where the volume of run-off is so rge that vegetated outlets are inadequate. The use of mechanically otected outlets is further limited by economic considerations.

Will the income from the land justify the expense of installation? re other types impracticable? Before the use of mechanically pro- cted outlets is decided upon, these questions should be answered.

Mechanical protection in outlets will be used most extensively as supplement to vegetation. Some form of structure is often re- ired at strategic points in grassed outlets, particularly toward the wer ends, where the larger volume of run-off or an abrupt over- ll may render protection by vegetation inadequate. In some areas ere has been a tendency in the past to underestimate the value of od sod covers, and many overfall structures have been used at ints in outlets where a properly designed and constructed sod me would have served the purpose just as well.

If vegetation and mechanical protection are used in the same chan- l the vegetation is usually in the upper reaches of the channel and e mechanical protection in the lower portion. It is usually not nsidered a good plan to use vegetation between or below structures r the purpose of allowing a steeper channel grade. Should the getal cover fail, the more expensive structure would also be exposed failure. If it is necessary to use mechanical protection, only per- anent structures of the best design should be used. Inexpensive readers and other temporary structures have not generally proved be of any material benefit in facilitating the establishment of getation in outlet channels and have frequently been a detriment.

HYDRAULICS

In the design and construction of all channels for the conveyance run-off, certain fundamental hydraulic principles must be observed order to assure satisfactory results. The size of drainage areas d the rates of run-off to be expected should be determined. Dimen- ons and velocities of drainageways also have to be computed. rainageways must be made large enough to carry the run-off during avy storms without overtopping, and they must be constructed so to avoid undesirable channel velocities. Sufficient field observa- ons and measurements have been made to enable engineers to com- te the size and proportions of drainageways with reasonable curacy, and they have made up tables that materially simplify these mputations. These tables are sufficiently accurate for all practical purposes. If greater accuracy is desired, computations for any particular job can be made by the use of certain engineering formulas and mathematical analysis. For large projects or unusual conditions individual computations are generally desirable, and a competent engineer should ordinarily be consulted.

RUN-OFF

In the computation of required drainageway or channel capacities the maximum rate at which run-off will be discharged from the contributing watershed is more significant than the total amount discharged or the average rate at which it is discharged. Drainageways must have sufficient capacity to convey run-off at the maximum rates that are commonly produced; otherwise excessive overtopping and damage is to be expected during periods of heavy rainfall. The maximum run-off rates for which drainageways are designed usually occur when rains of high intensities fall on saturated or frozen soil and during periods when the fields may be without crops. The maximum run-off rates for which drainageway channels and structures should ordinarily be designed are given in table 2 for different kinds and sizes of watersheds in various sections of the United States. If additional information on rainfall is desired, it can be found in United States Department of Agriculture Miscellaneous Publication 204, Rainfall Intensity-Frequency Data, which gives maximum rates of rainfall that are likely to occur in different localities during periods of 2, 5, 10, 25, and 100 years.

CHANNEL CAPACITIES AND VELOCITIES

Securing adequate capacity and avoiding detrimental scouring and silting velocities are the main hydraulic requirements in the design of drainageways and outlet channels. Controlling velocity is largely a matter of regulating the proportions of channels. Safe maximum channel velocities are dependent upon the erosion-resistant properties of the material used to line the channel. Concrete or metal linings will withstand much higher velocities than sod covers. Since different types of sod covers vary in their ability to resist run-off velocities, the highest velocity for which a drainageway can be designed will depend on the cover to be used. Unlined earth channels offer the least resistance to erosion and can be used only for comparatively low velocities. The velocity in a run-off-disposal channel increases not only as the slope of the channel increases, but as the average water depth (approximately the hydraulic radius) increases and as the surface resistance (coefficient of roughness) decreases. Once the outlet location and type of protection have been selected, it is difficult to change the channel slope or resistance factor, so control of velocity is largely obtained by regulating the average water depth. In wide, shallow channels the velocities are lower than in narrow, deep channels.

Field observations indicate that well-established Bermuda sod outlets can safely withstand velocities of 7 to 8 feet per second for periods of intense run-off ordinarily experienced under normal rainfall con-

ABLE 2.—*Maximum run-off to be expected once in 10 years from drainage areas of 1 to 300 acres*

Watershed aracteristics [1]	Group [2]	Run-off from drainage area of—											
		1 acre	2 acres	3 acres	4 acres	5 acres	10 acres	15 acres	20 acres	25 acres	30 acres	35 acres	40 acres
		Cu. ft. per sec.	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft.per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
lling timber	1	2	4	5	6	8	16	23	29	35	39	44	49
	2	2	3	4	6	8	15	21	26	32	35	40	45
	3	2	3	4	5	7	13	19	23	28	31	35	39
ly timber	1	3	5	6	8	9	18	27	33	40	45	52	57
	2	3	4	6	8	9	17	25	31	36	41	47	52
	3	3	4	5	7	8	15	22	27	32	36	41	45
lling pasture	1	5	8	12	15	18	33	47	58	67	77	87	99
	2	4	8	11	14	17	30	43	53	61	70	79	90
	3	4	7	10	13	15	27	38	47	54	61	69	78
ly pasture	1	7	13	16	20	24	40	55	67	79	91	102	114
	2	7	12	15	19	22	37	51	61	72	82	93	104
	3	6	11	14	17	20	33	45	54	63	72	81	90
lling cultivat-d	1	8	15	23	29	34	57	77	95	111	128	145	162
	2	8	14	22	27	32	53	71	87	101	116	132	147
	3	7	13	20	25	29	47	63	77	89	102	115	128
ly cultivated	1	10	17	27	35	42	70	94	114	134	154	174	196
	2	10	16	25	33	40	64	86	104	124	139	158	177
	3	9	15	23	30	36	57	76	92	107	122	138	154
raced rolling ultivated	1	6	9	14	18	21	40	54	68	81	93	107	120
	2	5	9	13	16	20	36	50	62	73	84	97	109
	3	5	8	12	15	18	33	44	55	65	74	85	95

Watershed characteristics [1]	Group [2]	Run-off from drainage area of—										
		45 acres	50 acres	60 acres	70 acres	80 acres	90 acres	100 acres	150 acres	200 acres	250 acres	300 acres
		Cu. ft. per sec.	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
lling timber	1	55	62	73	83	90	97	100	145	185	216	245
	2	50	56	65	74	80	86	91	127	160	186	210
	3	43	48	56	63	68	73	77	105	130	150	168
ly timber	1	64	71	85	96	104	114	122	165	213	252	285
	2	58	64	75	85	92	102	108	145	184	217	244
	3	50	55	65	73	79	86	91	120	150	175	195
lling pasture	1	110	121	143	164	181	197	208	290	369	433	489
	2	99	109	128	146	160	175	185	254	319	371	419
	3	86	94	110	125	137	148	155	210	260	300	335
ly pasture	1	128	142	166	190	210	227	241	334	426	497	572
	2	116	128	148	169	186	202	214	294	369	428	490
	3	100	110	128	145	159	171	180	242	300	345	392
lling cultivated	1	182	201	238	271	299	324	344	476	605	720	822
	2	164	181	212	242	265	288	306	419	522	620	703
	3	142	156	183	207	226	244	257	345	425	500	562
ly cultivated	1	219	241	285	323	358	389	416	580	727	863	986
	2	198	217	254	288	317	345	369	590	630	742	843
	3	171	187	219	246	271	292	310	420	512	600	675
raced rolling culti-ated	1	137	155	189	223	264	293	315	465	605	720	831
	2	124	139	168	199	234	260	280	409	522	620	712
	3	107	120	145	170	200	220	235	337	425	500	570

"Rolling" and "hilly" correspond to slopes of 5 to 10 percent and 10 to 30 percent, respectively.

Group 1 includes the entire States of Florida and Louisiana, the southern part of Georgia and Alabama, southern half of Mississippi, and the southeastern part of Texas. Group 2 includes central Texas, all of lahoma except the Panhandle section, the eastern half of Kansas, southeastern Nebraska, the southern of Iowa, western Illinois, all but the southeastern tip of Missouri, Arkansas except for the northeastern ner, South Carolina, those parts of Mississippi, Alabama, and Georgia not covered in group 1 (except xtreme northern parts of these States), the eastern and central part of North Carolina and Virginia, aware, the eastern half of Maryland, New Jersey, and the southern extremes of Connecticut and Rhode nd. Group 3 may be used for all other areas, except where local information indicates higher run-off rates.

ditions. This velocity has occasionally been exceeded for short periods without harmful results. It is believed that good bluegrass sod will withstand similar velocities, but bluegrass is usually more difficult to establish and maintain than Bermuda sod. Consequently the maximum velocities for which drainageways protected by bluegrass have been designed have usually been only 5 to 6 feet per second. A lower maximum channel velocity is frequently necessary where the climate or soil conditions or seeded meadow grasses produce less resistant covers. For example, recent experimental tests indicate that velocities of 3 to 4 feet per second should not be exceeded in channels protected by lespedeza. Low channel velocities (less than 2 to 3 feet per second) may cause undue silting in vegetated outlets, which will ultimately lead to inadequate channel capacity and overtopping. It is not always possible to eliminate velocities that leave silt in drainageways, but excessive silting can be minimized to a large extent if adequate conservation practices are used on the contributing watershed. Avoiding excessive terrace grades and spacing and properly maintaining outlet channels are particularly effective. If necessary, channel cross sections can often be adjusted, even on comparatively flat slopes, to avoid low or silt-depositing velocities. Using V-shaped channels with little or no bottom width will aid in maintaining desired velocities on flat slopes. An attempt should be made to secure as uniform a velocity as is practical throughout the entire length of an outlet.

The rate at which a channel will convey run-off is determined by multiplying the channel velocity by the water cross-sectional area. This cross-sectional area can be determined by multiplying the average water depth by the width. For example, a channel with an average water depth of 1 foot, a width of 8 feet, and a velocity of 5 feet per second will carry $1 \times 8 \times 5$, or 40, cubic feet per second. Because of the uncertainty concerning the amount and rate of run-off and the difficulty of maintaining exact dimensions under field conditions it is standard practice in determining the size of the channel to be constructed to provide a safety factor by making the channel slightly larger than the computed requirements.

It is much simpler to secure the required discharge velocities and capacities for pasture- and meadow-strip drainageways than for channel-type outlets. The minimum practical width of a grassed drainageway that can be used for hay or pasture (seldom less than 75 feet) usually provides ample capacity to carry the run-off from the contributing watershed and to take care of some silting, if silting cannot be entirely prevented. These strip-type drainageways on large watersheds should ordinarily have at least 1 to 2 feet of width for each acre of drainage area. Greater widths may be necessary if the curvature across the drainageway is unusually flat. If it is desirable to use grassed outlets of the channel type, the construction dimensions are usually determined by the velocity and capacity requirements. The channel dimensions (depth and bottom width) for assumed channel velocities and side slopes and various slopes and quantities of run-off are given in table 3. If other side slopes are used or if it is necessary to use lower velocities, it will be necessary to make separate computations. For small drainage areas V-shaped

ABLE 3.—*Approximate dimensions of outlet channels with grass covers capable of resisting maximum average channel velocities of 5, 6, or 7 feet per second, with 4:1 side slopes and with good channel conditions*

5 FEET PER SECOND

Dimensions	Dimensions required for discharge per second of—																	
	20 cubic feet	30 cubic feet	40 cubic feet	50 cubic feet	60 cubic feet	70 cubic feet	80 cubic feet	90 cubic feet	100 cubic feet	110 cubic feet	120 cubic feet	130 cubic feet	140 cubic feet	160 cubic feet	180 cubic feet	200 cubic feet	220 cubic feet	240 cubic feet
Width......feet	12	19½	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	4	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	10½	17½	24	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	4	4	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	10¼	15½	21½	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	4½	4½	4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	7½	13¼	18¾	24½	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	5	5	5	4½	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	5½	10¾	15¾	21	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	6½	5	5½	5½	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	2¼	8¼	12½	17	21½	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	9	7	5½	5½	5	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	----	4½	8¾	12¾	16½	20¼	24½	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	----	9½	8½	8	7½	7½	7	----	----	----	----	----	----	----	----	----	----	----
Width......feet	----	----	1½	6¾	10½	13¾	16¾	20	23	----	----	----	----	----	----	----	----	----
Depth...inches	----	----	14½	11	10½	10	9½	9½	9	----	----	----	----	----	----	----	----	----
Width......feet	----	----	----	----	----	----	5¼	8½	11½	14¼	16½	19	21¼	----	----	----	----	----
Depth...inches	----	----	----	----	----	----	18	16	15	14	14	13	13	----	----	----	----	----

6 FEET PER SECOND

Dimensions	20 cubic feet	30 cubic feet	40 cubic feet	50 cubic feet	60 cubic feet	70 cubic feet	80 cubic feet	90 cubic feet	100 cubic feet	110 cubic feet	120 cubic feet	130 cubic feet	140 cubic feet	160 cubic feet	180 cubic feet	200 cubic feet	220 cubic feet	240 cubic feet
Width......feet	5½	10¼	15	19¾	24¼	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	6	5	5	5	5	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	4	9	13	17¾	22	----	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	6½	6	5	5	5	----	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	1¾	7¼	11½	15½	19½	23½	----	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	8½	6½	6	6	6	5½	----	----	----	----	----	----	----	----	----	----	----	----
Width......feet	----	5¼	9½	13	16½	20½	24	----	----	----	----	----	----	----	----	----	----	----
Depth...inches	----	7½	7	6½	6½	6	6	----	----	----	----	----	----	----	----	----	----	----
Width......feet	----	2	6¾	10¼	13½	17	20½	23¾	----	----	----	----	----	----	----	----	----	----
Depth...inches	----	11	8½	8	7½	7	7	7	----	----	----	----	----	----	----	----	----	----
Width......feet	----	----	2¼	6¾	10	13	15¾	18¾	21½	----	----	----	----	----	----	----	----	----
Depth...inches	----	----	12½	10	9	9	8½	8½	8	----	----	----	----	----	----	----	----	----
Width......feet	----	----	----	----	4¾	8¼	11	13½	16	18¼	20¾	23¼	----	----	----	----	----	----
Depth...inches	----	----	----	----	13	12	11	10½	10½	10	10	10	----	----	----	----	----	----
Width......feet	----	----	----	----	----	----	----	4¾	8	10¼	12½	15	17	20¾	----	----	----	----
Depth...inches	----	----	----	----	----	----	----	17	15	14½	14	13½	13	13	----	----	----	----
Width......feet	----	----	----	----	----	----	----	----	----	----	----	----	----	6	10¼	14	17	----
Depth...inches	----	----	----	----	----	----	----	----	----	----	----	----	----	23	21	20	19	----

7 FEET PER SECOND

Dimensions	20 cubic feet	30 cubic feet	40 cubic feet	50 cubic feet	60 cubic feet	70 cubic feet	80 cubic feet	90 cubic feet	100 cubic feet	110 cubic feet	120 cubic feet	130 cubic feet	140 cubic feet	160 cubic feet	180 cubic feet	200 cubic feet	220 cubic feet	240 cubic feet
Width......feet	----	3¾	7¾	11	14¼	17¼	20½	23½	----	----	----	----	----	----	----	----	----	----
Depth...inches	----	8	7	6½	6½	6	6	6	----	----	----	----	----	----	----	----	----	----
Width......feet	----	1¼	6	9½	12¼	15¼	18¼	21½	----	----	----	----	----	----	----	----	----	----
Depth...inches	----	11	8	7½	7	7	7	6½	----	----	----	----	----	----	----	----	----	----
Width......feet	----	----	3¾	7½	10½	13	15¾	18¾	21½	----	----	----	----	----	----	----	----	----
Depth...inches	----	----	9½	8½	8	8	7½	7½	7	----	----	----	----	----	----	----	----	----
Width......feet	----	----	----	4½	8	10½	13	15¾	18¼	21	23	----	----	----	----	----	----	----
Depth...inches	----	----	----	10½	9½	9	8½	8½	8	8	8	----	----	----	----	----	----	----
Width......feet	----	----	----	----	4½	7¼	10	12½	14½	16¾	19	21¼	----	----	----	----	----	----
Depth...inches	----	----	----	----	12	11	10½	10	10	9½	9	9	----	----	----	----	----	----
Width......feet	----	----	----	----	----	----	4½	7¾	10¼	12¼	14¼	16¼	18¼	22	----	----	----	----
Depth...inches	----	----	----	----	----	----	14	13	12	11½	11½	11	11	11	----	----	----	----
Width......feet	----	----	----	----	----	----	----	----	1¾	5¼	7¾	10¼	12	15¾	19	22½	----	----
Depth...inches	----	----	----	----	----	----	----	----	20	17	15½	15	14	13½	13	13	----	----
Width......feet	----	----	----	----	----	----	----	----	----	----	----	----	----	5	9½	12¾	16	18½
Depth...inches	----	----	----	----	----	----	----	----	----	----	----	----	----	22	19	18	17½	17

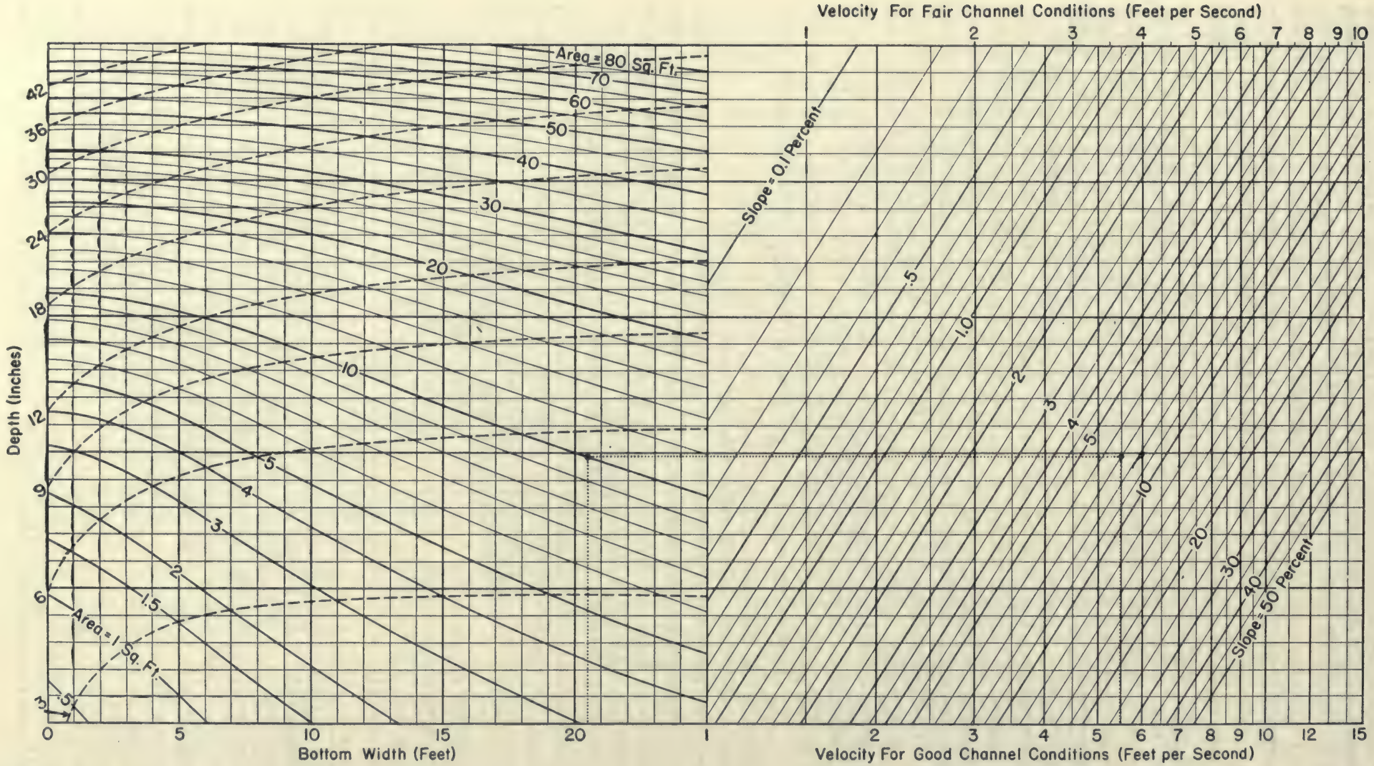


FIGURE 12.—Graphic solution of vegetated channel dimensions (trapezoidal cross section 4:1 side slopes) by the Manning formula. The light dotted line connects the points that represent the velocity, slope, cross-sectional area, and the corresponding depth and bottom width mentioned in the sample problem illustrating the use of the chart.

ditches are sometimes preferred. For flat-bottom channels, widths greater than 20 feet are seldom used. If a larger cross section is necessary to care for the run-off, two or more parallel channels are usually preferred to one wide channel.

A much wider range of velocity or other controlling channel conditions that may govern construction dimensions can be covered in a chart than in a table. Furthermore, many outlet channels will be constructed by contractors, surveyors, engineers, or even farmers who may prefer to use a chart rather than a table for determining the dimensions required. For this reason, figure 12 has been prepared. The chart can be used easily when one understands what the different lines and scales represent.

The chart is divided at the center into two distinct parts. On the right-hand side of the chart, the diagonal lines represent channel slopes and the vertical lines represent design velocities. The bottom scale on the vertical lines gives velocities for well-maintained, pliable-grass channels, such as Bermuda or bluegrass. The velocities are higher than those given at corresponding points on the top scale. The top scale is for poorly maintained channels or for coarse covers, such as lespedeza, which have a high frictional resistance to flowing water. On the left-hand side of the chart, the vertical lines represent channel-bottom widths, the dotted curved lines represent channel depths, and the solid curved lines represent channel cross-sectional areas.

To illustrate the use of the chart, suppose a terrace-outlet channel is to be constructed down a 7-percent slope and treated with bluegrass that is to be well maintained and capable of withstanding a maximum velocity of 5½ feet per second. The estimated maximum run-off to be provided for is 55 cubic feet per second. With this discharge and maximum velocity, the channel must have a cross-sectional area of $\frac{55}{5.5}$ or 10 square feet. To find the required channel depth and width, enter the right-hand side of the chart and locate the vertical line representing a channel velocity of 5½ feet per second for good channel conditions. Follow this line upward to the point of intersection with the diagonal line representing a slope of 7 percent. From this intersection pass horizontally to the left-hand side of the chart until the solid curved line representing a cross-sectional area of 10 square feet is intersected. From this point trace a line parallel to the vertical lines until it intersects the width scale and another parallel to the nearest dotted curved line until it intersects the depth scale. The reading on the width scale is about 20½ feet, and the corresponding reading on the depth scale is about 6 inches. In field practice an additional 6 inches of depth is provided for safety, so the constructed depth of the channel is 12 inches.

WEIR-NOTCH CAPACITIES

Structures that may be used in connection with the establishment of proper outlets or disposal systems will generally be of the weir-notch type. The notch, or opening, through which the run-off flows as it passes over the structure, must have adequate capacity to prevent overtopping and its resulting damage. A common cause of the failure of check dams is insufficient notch capacity. Table 4 gives, for various rates of run-off, the size of the weir notches that will be required for the type of check dams ordinarily used in outlet protection. It is usually desirable to select a notch width that is several times as wide as the depth of the notch in order to avoid undue concentration of the run-off as it passes over the structure. It is also standard practice to construct the notch slightly larger than necessary for computed run-off requirements to provide a factor of safety.

TABLE 4.—*Approximate discharge capacity of rectangular notches in small check dams*[1]

Depth of notch (feet)	Discharge capacity per second when the length of notch is—											
	2 feet	4 feet	6 feet	8 feet	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet	22 feet	24 feet
	Cubic feet	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*	*Cubic feet*
0.5	2.3	4.5	6.8	9.1	11.3	13.6	15.8	18.1	20.4	22.6	24.9	27.2
1.0	6.4	12.8	19.2	25.6	32.0	38.4	44.8	51.2	57.6	64.0	70.4	76.8
1.5	11.8	23.5	35.2	47.0	58.8	70.5	82.3	94.1	105.8	117.6	129.3	141.1
2.0	18.1	36.2	54.3	72.4	90.5	108.6	126.7	144.8	162.9	181.0	199.1	217.2
2.5	25.3	50.6	75.9	101.2	126.5	151.8	177.1	202.4	227.7	253.0	278.3	303.6
3.0	33.3	66.5	99.8	133.0	166.3	199.5	232.8	266.0	299.3	332.5	365.8	399.1
3.5	41.9	83.8	125.7	167.6	209.5	251.4	293.4	335.3	377.2	419.1	461.0	502.9
4.0	51.2	102.4	153.6	204.8	256.0	307.2	358.4	409.6	460.8	512.0	563.2	614.4
4.5	61.1	122.2	183.3	244.4	305.5	366.6	427.7	488.8	549.8	610.9	672.0	733.1
5.0	71.6	143.1	214.7	286.2	357.8	429.3	500.9	572.4	644.0	715.5	787.1	858.6

[1] Computed by formula $Q=3.2\ LH^{3/2}$, where $Q=$ discharge in cubic feet per second, L=length of notch in feet, and H=head of water on crest of notch in feet. For discharges in excess of those shown, the length may be increased proportionately if the same head is maintained. For example, the discharge capacity of a notch 28 feet long and 2.5 feet deep would be twice as large as that of a notch 14 feet long and 2.5 feet deep, or 354.2 cubic feet per second (2×177.1).

CONSTRUCTION OF VEGETATED DRAINAGEWAYS AND OUTLETS

Before complete plans can be made for establishing satisfactory drainageways or outlets on a farm the procedure to be used in preparing the channels and the seedbeds must be decided upon, as well as the method of establishment and the type of vegetation. To determine a practical manner of providing run-off protection during the period in which vegetation is being established is often difficult. The kind or the combination of grasses that will produce necessary protection in a comparatively short period in a given locality should be selected. Recommendations on these points are given in this section. Usually the construction procedure and types of vegetation used will be those most applicable to the locality.

GRADING DRAINAGEWAYS

In the formation of strip outlets, or grassed drainageways, only a minimum amount of excavation or fill work should be undertaken. Frequently the depression selected for run-off disposal will require no work of this kind. If small gullies, hummocks, ridges, sprouts, or shrubs are present, the gullies should be plowed or graded in, the hummocks and ridges leveled off, and the sprouts and shrubs removed.

Trees or shrubs in water channels of any type are usually undesirable because of their tendency to obstruct, divert, or concentrate the flow and cause meandering currents. Only such use of the scraper or drag as may be necessary to develop the depression into its natural cross section or provide a satisfactory seedbed can be justified. Extensive moving of earth or disturbance of soil not only increases the cost of preparation but also usually makes the establishment of the necessary vegetation more difficult.

If the run-off is to be restricted to narrow channels, some excavating and moving of earth is usually required to provide the desired capacity and cross sections. This work can generally be done most effectively with a grader, terracing machine, or scraper. The channels should be shaped up to provide the required cross-sectional area (table 3), and flat side slopes (usually 4:1 or flatter) should be provided so that mowing and the maintenance of channels will be facilitated. Sometimes it may be necessary to level off small washes or ridges in forming the channel. In areas where topsoil is shallow, subsoil unproductive, and grass covers difficult to establish, it has been found desirable to do only the minimum amount of excavating within the channel and to build the sides or channel berms as far as possible by grading the earth up from the outside of the channel. This practice greatly reduces the amount of topsoil removed from the channel and the subsequent work and fertilization required to produce a satisfactory plant cover. If channels are excavated into infertile subsoils it is frequently impossible to establish the desired cover.

The construction of channel berms mainly from the outside may become objectionable if proper end drainage of furrows produced by certain contour row crops is important. It is often desirable to provide furrow drainage for row crops if bedding is practiced, as in potato and cotton culture, or if contour listing is used and furrows of considerable size are produced. Where cultivating produces furrows that have only a small cross-sectional area and where the relief is uneven, row drainage is not so important because the furrows invariably overtop during most rains before the water reaches the end of the rows. The problem is sometimes solved by the use of a vegetated strip along the outside of the outlet channel to facilitate necessary row drainage and provide a turning strip. In other cases, it will be necessary to adjust the amount of channel excavation according to the size of channel required, the depth of soil, the ease of establishing cover, and the necessity for row drainage into the outlet channel.

The berms along outlet channels should have flat enough side slopes to facilitate mowing, and surplus earth excavated from the channel should be spread out, so that it will not form a field barrier. Sometimes it can be conveniently used for making nearby terrace fills. If overfalls in the drainageway or outlet channel are to be protected by means of structures or sod flumes they should be excavated and shaped up to the required structural dimensions. Considerable expense and time can often be saved by doing as much of this excavating as possible with a team and scraper.

ALINEMENT OF TERRACES AND OUTLETS

If individual outlets are used, the ends of the terraces should be shaped and arranged so as to give the minimum concentration of run-off on the outlet slopes. The outlet end of the terrace channel should be wide and flat, so that it will discharge the run-off in a wide, shallow sheet. The vegetation should be extended into the terrace channel so that this wide cross section can be maintained and the development of excess channel grades near the outlet end prevented. If the natural slope of the area onto which the run-off is to be discharged is uniform and parallel to the direction of flow in the terraces, the terraces need extend only far enough into the outlet area to assure the discharge of the run-off onto the vegetated slope. If the natural slope of the area onto which the run-off is to be discharged is at right angles to the terrace flow, it is usually advisable to extend the upper terrace a considerable distance into the grassed slope and systematically reduce the extension of each subsequent terrace down the slope, so that concentration of the discharge from adjacent terraces can be minimized. If the slope of the grassed outlet area is intermediate, that is, neither parallel to the direction of flow in the terrace nor at right angles to it, it may be necessary to make an irregular extension of the terraces to prevent so far as possible excessive concentration of run-off.

Where any type of a collective outlet is used, and particularly where the outlet channel is located in a natural depression, it is often advantageous to turn the ends of the terrace down grade for a short section back from the outlet. By turning the last 50 to 100 feet of a terrace somewhat downhill and providing a corresponding reduction in the depth of channel cut on the upper side, it is possible to bring the bottom of the terrace channel into the outlet channel at or close to ground level without changing the normal terrace grade. In order to do this the last section of the terrace is sometimes constructed with a scraper or fresno, so that more and more of the dirt can be moved from the lower side as the terrace approaches the outlet channel. If it is considered advisable to build the terrace through to the outlet with a grader in the usual manner, the excess terrace grade can be eliminated by placing a small sodded earth fill to the required height across the end of the terrace channel, provided a corresponding increase is made in the height to maintain the necessary channel capacity. The excess excavation in the terrace channel will soon become filled with silt. Turning the ends of terraces downhill makes it easier to get the required channel depth below the outlet elevation of the terrace channel without excessive excavation in the outlet channel. This practice also allows the terraces to have a much straighter approach if the outlet channel is located in a natural depression. Necessary precautions should be taken to prevent excess grades in the terrace channel and maintain adequate capacity.

In order to provide a factor of safety against overtopping, silt accumulation, and insufficient drainage in the terrace channel, grassed outlet channels should be at least 6 inches deeper than the minimum depth required for the discharge capacities. The bottom of the outlet channel should be several inches below the elevation of the terrace channel at the outlet end, and this overfall should be sloped (at least 4:1) and well sodded to prevent it from advancing up the terrace channel (fig. 13). If the procedure used to establish the sod cover tends to reduce the channel depth, as sodding would, for example, the initial channel depth should be increased sufficiently to compensate for this reduction.

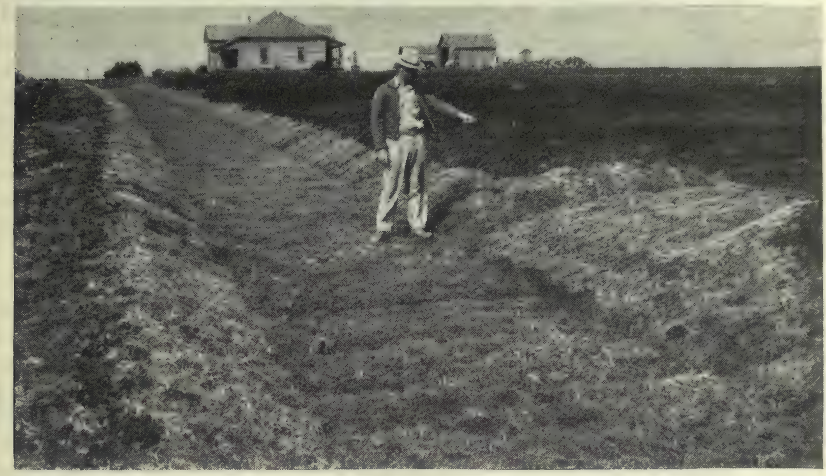


FIGURE 13.—A sodded terrace-outlet channel. Note how the terrace channel is shaped and protected at the discharge end. The broad, flat, sodded section spreads the run-off as it enters the outlet channel and prevents overfalls from advancing up the terrace channel.

If vegetation in the outlet is established before the terraces are constructed, it is generally advisable to terminate terrace construction with the regular terrace equipment far enough back from the outlet so that there will be ample room for turning without damaging the vegetation in the outlet. Each of the terraces can be connected with the outlet channel by constructing this last section with a fresno or scraper. With fresno construction, the team and scraper are worked back and forth over the terrace without injury to the vegetation in the outlet. If a grassed outlet is used as a turning area for heavy construction equipment the vegetation may be damaged to such an extent as to render repair difficult. Fresno construction of the terrace section near the outlet also makes it easier to produce a broad discharge channel to facilitate the maximum spread of the run-off as it leaves the terrace channel. Often it is also necessary to finish terrace construction in this way where terraces terminate at permanent fences or hedgerows.

ESTABLISHING VEGETATION

In many areas it has been found not only hazardous but also expensive to attempt to establish vegetation in drainageways or outlet channels when they are being used for the disposal of run-off. Ordinary seeding procedure, with the necessary fertilization and seedbed preparation, usually provides the cheapest means of establishing grass covers and wherever practical should be followed to reduce the cost of outlets. Newly prepared seedbeds, seeds, fertilizers, and young plants offer little resistance to erosion and are frequently washed out unless special precautions are taken or special practices adopted. Solid or strip sod, if properly anchored, will sometimes carry run-off without harmful results immediately after it has been placed. Sodding is more costly than seeding, however, and the additional expense of sodding may retard the extensive use of vegetative protection. It is sometimes even difficult to anchor newly placed sod in certain channels in such a way that it will not be damaged by heavy run-off. Damage from run-off is more acute in the establishment of vegetation in outlet channels than in wide grassed drainageways because of the higher velocities in the channels. There are several methods that can often be used to save expense and eliminate these hazards in establishing vegetation in outlets.

The first method that should be considered is establishing the outlets before the terraces are constructed. With proper planning, this can often be done, particularly if a complete soil conservation plan for the farm is to be adopted. Complete land use and run-off-disposal plans should be developed at the outset, so that the first outlets or drainageways will be a part of the final plans for the area. When the vegetation is well enough established to withstand additional run-off the terraces can be constructed and connected with the outlet. On some farms several types of outlets will be used, and financial circumstances often will not permit immediate construction of all the necessary terraces and outlets. Under these conditions, areas for which natural outlets are available or for which the outlet channels require solid sodding or mechanical protection can be terraced the first year, while the vegetation is becoming established in other outlets.

Another practice that has facilitated the use of the simpler and cheaper methods of establishing vegetation is diverting the run-off through a temporary bypass until the vegetation in the permanent drainageway becomes established (fig. 14). This procedure can often be used on unterraced as well as terraced areas. On terraced areas this usually requires breaking the terraces or extending them across the permanent outlet channel to a temporary ditch that will carry the run-off without excessive damage until the necessary vegetation is established. Topographical features, the extra work involved, and the extent of the damage that may occur in the temporary channel will largely determine the practicability of this practice.

Subsoiling or other run-off-retention measures may often be used alone or in combination with other practices to facilitate satisfactory establishment of vegetation in drainageways or outlets. Such run-off-retention methods as contour ridging, furrowing, listing, and subsoiling on the contributing watersheds are practical in some places and may sufficiently reduce the run-off on certain soil types to make it possible to establish the necessary vegetation in drainageways. On some of the demonstration projects of the Soil Conservation Service it was found that subsoiling terrace channels and outlets to a depth of about 18 inches reduced the run-off sufficiently during the following year to permit the establishment of necessary plant covers in the outlets.

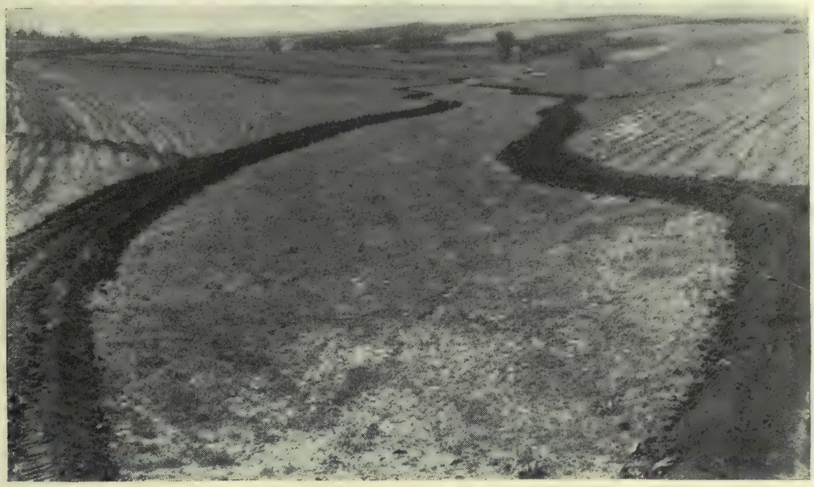


FIGURE 14.—This seeded drainageway is protected from run-off by temporary ditches along the sides of the seeded area. After the vegetation has become established the temporary ditches will be plowed in, and the run-off will then flow down the vegetated drainageway.

Mulching of seeded channels and drainageways has made possible the successful establishment of sod covers by seeding in many areas where seeding otherwise would have been a failure (fig. 15). Properly anchored mulch not only protects the newly prepared seedbed, seeds, and small plants from run-off and hard rains but conserves moisture and produces a surface condition that encourages the germination and growth of small grass seeds. The mulch is produced by spreading a thin but continuous layer of straw, corn fodder, old hay, or brush over the entire seeded area. Two or three tons per acre is usually required. The mulch is anchored by lightweight woven wire or by strands of baling wire on 6- to 12-inch centers. The wire should be staked down every few feet so as to prevent the removal of the mulch by run-off or winds and to hold it in close contact with the ground surface. By the time the grass roots have become established, the mulch is usually rotted sufficiently to make its removal unnecessary, but the wire should be removed before the grass is mowed or grazed. If brush is used, it can be staked down at intervals.

On small areas or at vulnerable points in larger areas, loosely woven burlap tightly drawn and staked to hold it in place has often provided satisfactory protection (fig. 16). This covering retains the moisture and prevents erosion or washing. It may be particularly effective if a turf is to be established on short, steep slopes. Old burlap bags ripped apart or some of the commercial fabrics now on the market may be used. If an open material is used the grass will come up through the meshes; since the covering will soon decay, it need not be removed.

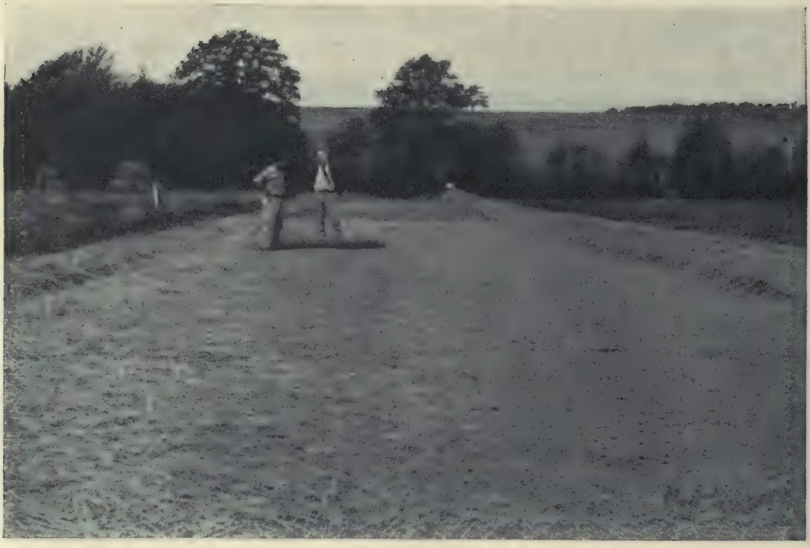


FIGURE 15.—A seeded drainageway protected by a straw mulch held in place by fine-mesh poultry wire. The wire will be removed when the vegetation becomes established.

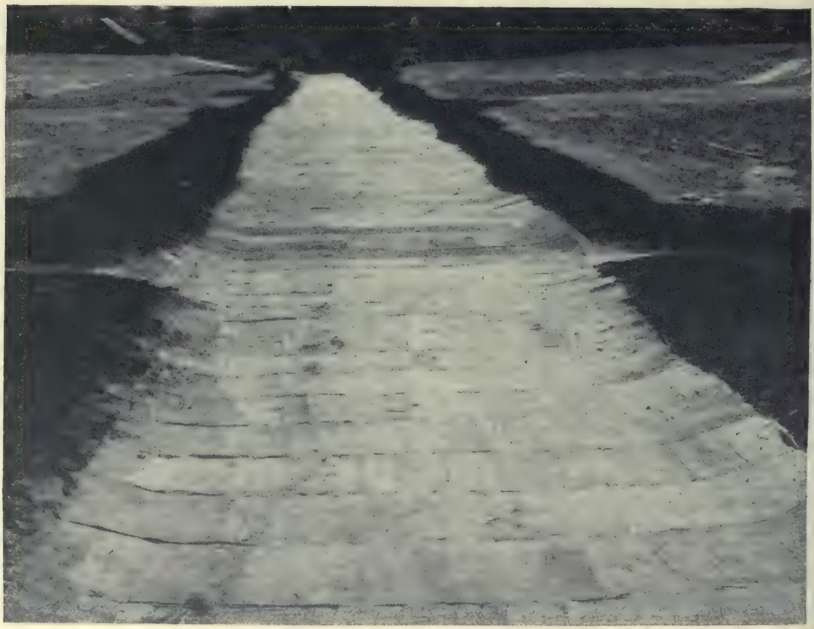


FIGURE 16.—The burlap sacks will give protection in this newly prepared and seeded outlet channel until the vegetation becomes well enough established to carry the run-off safely.

SEEDING

Wherever suitable grass varieties can be readily established from seed the cheapest sod covers can usually be produced by seeding. In some sections where large areas must be vegetated to dispose of run-off, seeding is frequently the only practical method of establishing the necessary protection. This is particularly true in areas where Bermuda grass cannot be used, and even Bermuda, which is most commonly established from stolons, has frequently been established by seed. In other areas seeding is often used in combination with the direct transplanting of sod. Success with seeding is dependent not only on protecting the seed from run-off but also on the use of suitable seed mixtures, good seedbed preparation, ample fertilization, and proper methods of seeding. Since the ultimate success not only of the drainageway but also of any conservation measures on the contributing watershed is dependent on the establishment of a satisfactory cover in the drainageway, heavy applications of seed and fertilizer can usually be justified. Where water is available some artificial watering during periods of drought may even produce profitable results.

It cannot be expected that grasses and legumes can be established readily by seed where the topsoil has been washed away and the fertility of the remaining soil is low. Subsoil as a rule does not respond successfully to the seeding of grasses, even with applications of fertilizer and lime. The fertility must be built up with heavy applications of manure, fertilizer, and lime and by turning under legume crops for green manure. If economically feasible, complete sodding is the surest means of obtaining a satisfactory drainageway under such conditions.

After the drainageway has been properly shaped, a firm seedbed should be prepared by the customary cultural operations (figs. 17 and 18). If a fertilizer is necessary, well-rotted barnyard manure is often the most satisfactory; if a sufficient quantity is available, sometimes as much as 15 to 20 tons per acre should be applied. It can be worked into the soil during the grading and seedbed preparation. Superphosphate at the rate of 400 pounds per acre or its equivalent in basic slag should be used with the manure in humid regions. If manure is not available, a complete commercial fertilizer high in nitrogen, such as 6–2–4 or a 6–12–4, can be used at the rate of 400 to 600 pounds per acre. Commercial fertilizers are generally broadcast and raked into the soil, after which the soil is firmed with a packer. The seed mixture can be broadcast immediately. Sour soils should be limed in accordance with local requirements.

The species of grasses and legumes that should be seeded will vary in different parts of the country. Selection should be based upon the adaptability of the grasses to the locality in which they are to be used, their aggressiveness, and their ability to resist erosion and silting. The use to be made of the seeded area will also govern to some extent the selection of species to be seeded.

Sod-forming grasses are generally preferred to bunch grasses. where both are adapted, because they make a denser turf and a more

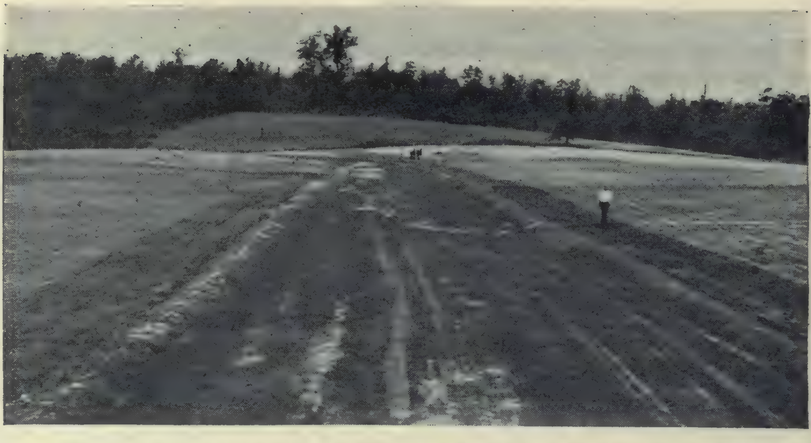


FIGURE 17.—This drainageway has been shaped to proper cross section and seeded for run-off disposal. Note the small earth embankments along the sides, used to protect temporarily the seedbed and young plants.

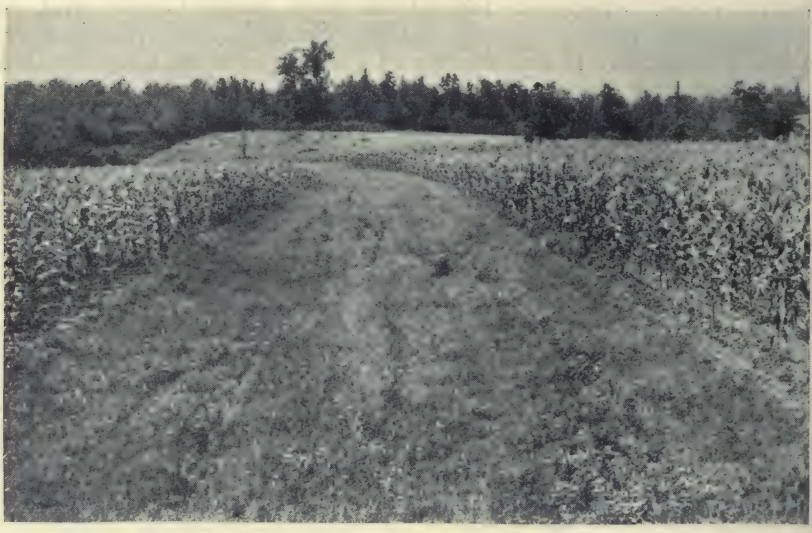


FIGURE 18.—The drainageway shown in figure 17 after the vegetation had been established and the temporary embankment removed.

uniform ground cover. It is generally advisable to seed simple mixtures of adapted grasses and legumes to insure complete stands and early stabilization of the drainageway. As the less well-adapted species thin out, the more aggressive ones will spread to replace them and thus perpetuate a complete ground cover.

In the larger drainageways, where it may be impossible to provide sufficient run-off protection, sowing a quick-growing annual crop to stabilize the drainageway before seeding the grasses is often advisable. Small grains, Sudan grass, domestic ryegrass, and similar crops may be seeded in the spring to hold the soil effectively and produce a residue in which to seed the grasses the following fall. Nurse crops may also be seeded with the grasses to afford quick protection, but care must be taken not to seed the nurse crop so thick that it will compete for moisture to the elimination of the grasses or become so thick as to smother the small grass and legume plants. One or two pecks per acre of barley, oats, or other small grain should be sufficient. When the nurse crop becomes tall or too vigorous it should be cut to reduce competition and prevent smothering of the slower growing and more permanent vegetation.

Grass and legume mixtures for pastures are generally seeded 20 to 30 pounds to the acre. Heavier seeding is usually advisable in drainageways, where a thick grass cover is desirable, since some of the seed may be washed away. Thirty-five to forty-five pounds per acre can be used safely in drainageways and outlets that have been properly fertilized, as moisture conditions are generally ideal to support a thick stand. If there is little plant food or moisture, however, heavy application of seed may cause a complete failure.

Since the most desirable species of grasses and mixtures will vary considerably with local soil conditions and climate, it is difficult to give definite recommendations that would apply to all localities. Specific recommendations as to the most suitable grasses should be obtained from the local county agent, State experiment station, or field representative of the Soil Conservation Service.

Early fall seeding usually gives the best results, but some variation in seeding dates is necessary. The southern or less hardy grasses require early spring seeding. In the central and northern Great Plains and western Corn Belt, where grasshoppers are numerous, late-fall seedings are advisable.

Seeding may be accomplished by broadcasting or by drilling. If the seed is broadcast the ground should be firmed by a packer, seeded, and then harrowed lightly to cover the seed. Some plants, as for instance *Lespedeza sericea*, give better stands if the harrowing is omitted. In the semiarid sections drilling is much preferred to broadcasting. Because drilling places the seed in moist soil it gives more rapid and uniform germination and greater assurance of getting a satisfactory stand. To reduce the risk of having the seed washed away, contour tillage of the seedbed and contour drilling are preferred wherever practical. Tillage and drilling operations should at least be conducted in a zigzag pattern that crosses the area as often as is convenient. Even running the drill over the ground two or three times in this manner to plant the desired amount of seed may be advisable to assure more uniform seed distribution and eliminate the effect of rows as much as possible.

SODDING

Where sod is available on nearby areas and local conditions make the establishment of adequate cover by seeding excessively hazardous, it is often necessary to resort to direct transplanting of sod or grass roots. Several methods of transplanting sod have been developed

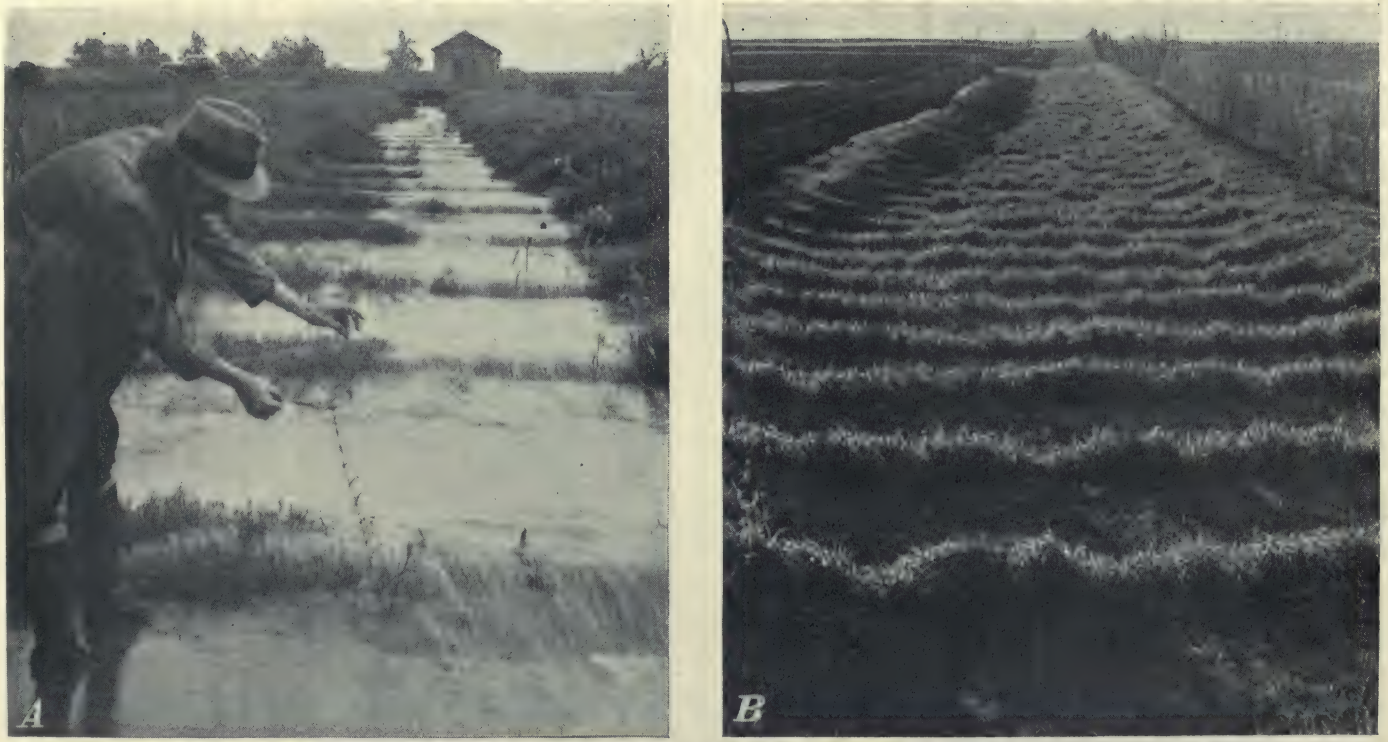


Figure 19.—*A*, These Bermuda grass strips protect the channel from erosion. The runners from the grass roots will soon spread over the intervening areas and provide a complete cover. *B*, A series of oat strips at comparatively close intervals provided sufficient protection in this outlet until the grass seeded over the entire channel became established.

that are adaptable to local conditions and various grasses. Strip sodding and solid sodding have been used in practically all areas, and sprigging, spot sodding, and broadcast sodding have been used with good results in many Bermuda grass areas of the Southern States. Strip sodding consists of laying sod in strips approximately on the contour and at regular intervals down the slope. Solid sodding is the transplanting of a continuous layer of sod over an area. Spot sodding is the transplanting of sprigs of grass roots or rootstocks more or less at random. They are usually placed at fairly close intervals. Broadcast sodding is the disking and removing of the topsoil and sod roots from a well-sodded area and the spreading of this mixture as a continuous mulch over the area to be treated.

Establishing plant cover by sodding is most common on areas where temporary run-off protection cannot be provided, where an immediate cover is necessary, or where run-off must be confined to restricted channels. For the best results with any sodding procedure, fertilization, good channel preparation, and careful handling and placing of the sod or roots are necessary. Recommendations for fertilization and sodding dates are similar to those given for seeding.

The use of strip sodding has generally been restricted to the flatter slopes, those of 5 percent or less, and to drainage areas of about 20 acres or less, from which the volume of run-off is not large (fig. 19). Even with these limitations there have been some failures, and some repair has been necessary in other cases because of the tendency for overfalls to develop below sod strips. This tendency has been particularly troublesome in sandy soils. The sod strips are usually cut 12 inches wide and 1 to 2 inches thick. They are placed either in a trench cut to the dimensions of the sod across the bottom of the outlet channel or directly on the channel bottom, and the area between strips is filled with fertile soil and seeded. In either case, the top of the sod strips should be flush with the bottom of the completed channel so the strips will not create unnecessary turbulence and will be less likely to wash out during run-off periods. The spacing of the sod strips has usually ranged from 3 to 6 feet, according to the slope of the channel, a 4-foot spacing commonly being used for average conditions. Whatever spacing is used, it is believed that the vertical interval between strips should seldom exceed the thickness of the sod. The sod strips should be extended up the sides of the channel to at least the maximum run-off depth anticipated.

Field observations have shown that the cost of strip sodding and the labor requirements have been almost as great as for solid sodding. Since strip sodding seldom gives as good results as solid sodding, its use can ordinarily be justified only in areas where there is insufficient sod for solid sodding.

Spot and broadcast sodding are sodding methods used in the establishment of Bermuda grass from rootstalks and stolons. Spot sodding is accomplished by planting rootstock sprigs in hand-made holes or by dropping them at desired intervals and plowing or disking them in. Disking is the more economical if large areas are to be covered. The root sprigs are usually placed on 12- to 24-inch centers and covered with 2 to 3 inches of soil, which is packed around them. If broadcast sodding is practiced, the area from which the sod is to be taken is usually disked so as to cut up the Bermuda grass roots and mix them with the topsoil. This mixture is removed by shovels, scrapers, or fresnos and spread in a continuous layer 1½ to 3 inches thick over the area to be sodded. For best results the area should then be disked and packed. This method has the advantage of adding considerable topsoil to infertile areas. The mulch of topsoil and roots offers some resistance to damage by rainfall and run-off although it is not nearly so effective in this respect as solid sodding. Broadcast sodding can be done economically, largely because the gathering and planting of the sod is done almost entirely by equipment. Hand labor is practically eliminated. In some areas a farm manure spreader has been used for spreading the grass roots and soil.

In bluegrass areas, where the less-expensive seeding procedure has been impractical, solid sodding has been more satisfactory. Even in Bermuda grass sections solid sodding has frequently been necessary where an immediate channel cover is required or where slopes are steep (fig. 20). The sod is cut from a well-grassed area and laid in continuous strips across the water channel and thoroughly tamped into place. It is usually cut in strips 1 foot wide and 1 to 2 inches thick. Transporting the sod strips on 6- to 10-foot boards, rather than attempting to roll them, has facilitated the moving of the sod. If newly laid sod is exposed to heavy run-off before the grass roots have had a chance to anchor the sod strips, it is frequently necessary to stake or staple the sod down at regular intervals. Anchorage by lightweight woven wire and stakes has been necessary in some places. The use of commercial or home-made sod cutters will materially assist in reducing the cost of sodding (figs. 21 and 22).

In some areas considerable expense has been saved by a combination of sodding and seeding procedures in establishing vegetation in drainageways. Strip or spot sodding with seeding of the intervening areas has been used in some sections. In others a low portion of the channel provided to carry the greatest amount of run-off is sodded and the remainder seeded. In wide V- or concave-shaped channels a strip several feet wide in the center of the channel is sodded solid, and the remainder of the cover is established by seeding. Occasional sod cut-off strips are extended up the sides of the drainageway to divert all low-flow run-off to the sodded portion. If terraces have been constructed, sodded strips should be provided to convey the run-off safely from each terrace channel to the sodded portion of the outlet channel.

CONSTRUCTION OF MECHANICALLY PROTECTED OUTLETS

Where it is necessary to provide mechanical protection in terrace outlets, low, permanent structures of the weir-notch type are usually used. They may be built of brick or stone masonry, reinforced concrete, precast concrete blocks, or a combination of these materials. Usually the materials available locally will be used. In areas where good-quality rock is available and where the labor necessary in quarrying and hauling is not excessive, rubble-masonry construction will usually be preferred. In order to provide a more stable structure

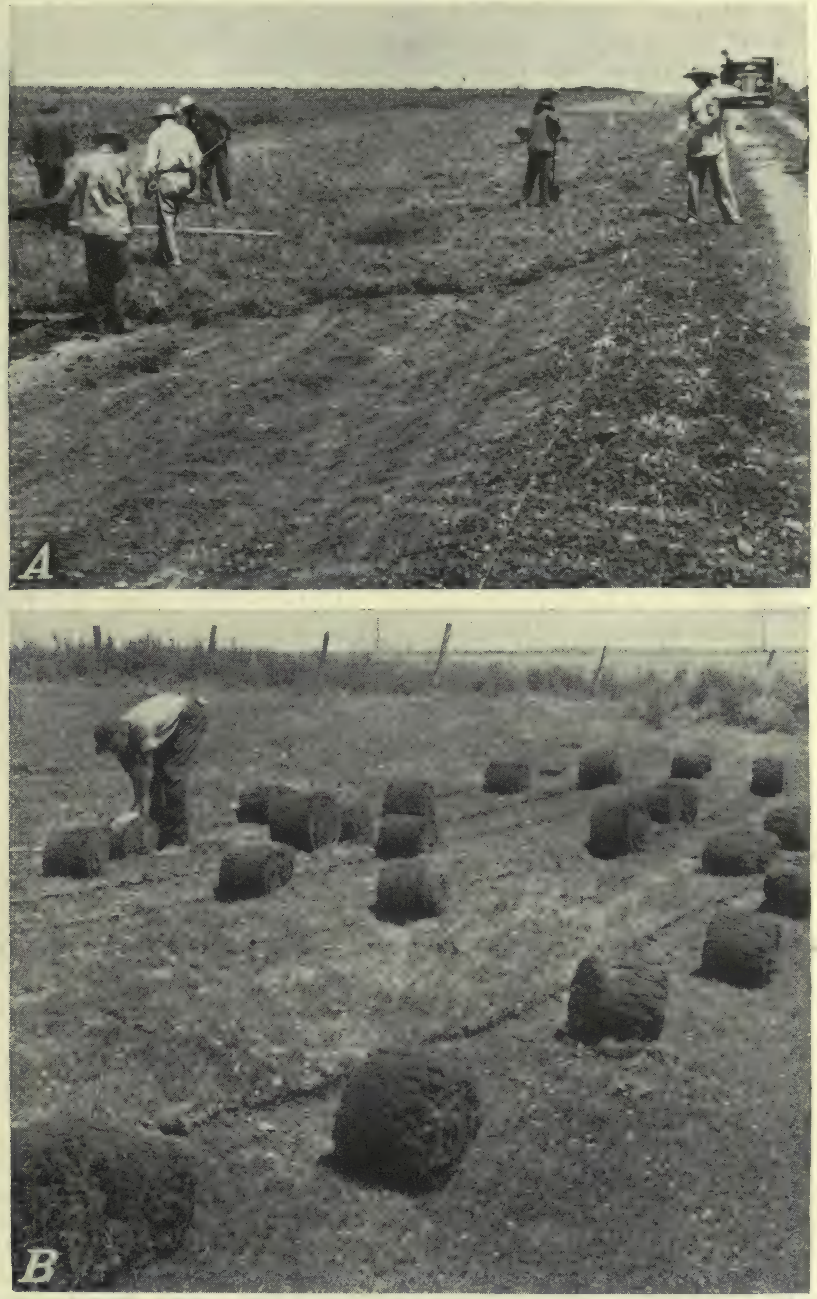


FIGURE 20.—*A*, Sod is being transplanted over this outlet channel in order to get a protective covering immediately; *B*, the sod has been cut and rolled preparatory to transportation to an area that is to be sodded.

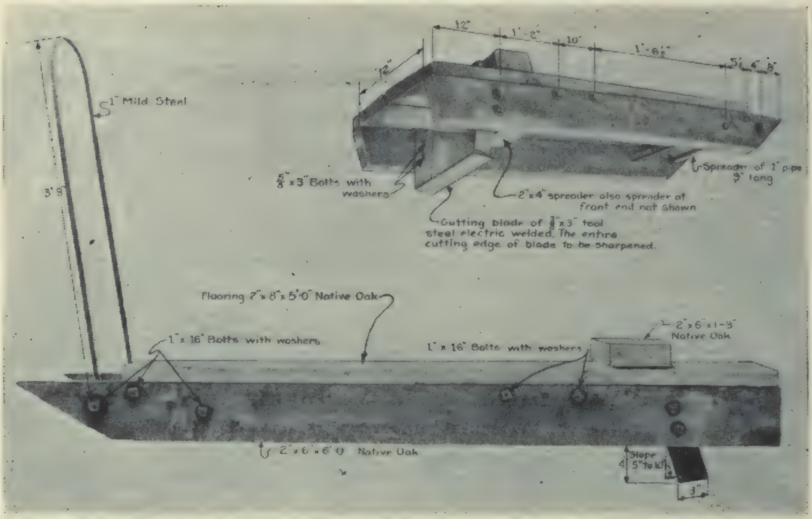

12"
1'-2"
10"
1'-6½"
5½
4"
8"
12"
1" Mild Steel
3'9"
⅝" x 3" Bolts with washers
2" x 4" spreader also spreader at front end not shown
Spreader of 1" pipe 9" long
Cutting blade of ⅜" x 3" tool steel electric welded. The entire cutting edge of blade to be sharpened.
Flooring 2" x 8" x 5'0" Native Oak
1" x 16" Bolts with washers
1" x 16" Bolts with washers
2" x 6" x 1'-3" Native Oak
2" x 6" x 6'0" Native Oak
Slope 5" to 10"
4
2
3"

FIGURE 21.—A home-made sled-type sod cutter. For satisfactory operation special care must be taken in the construction and adjustment of the cutting blade.

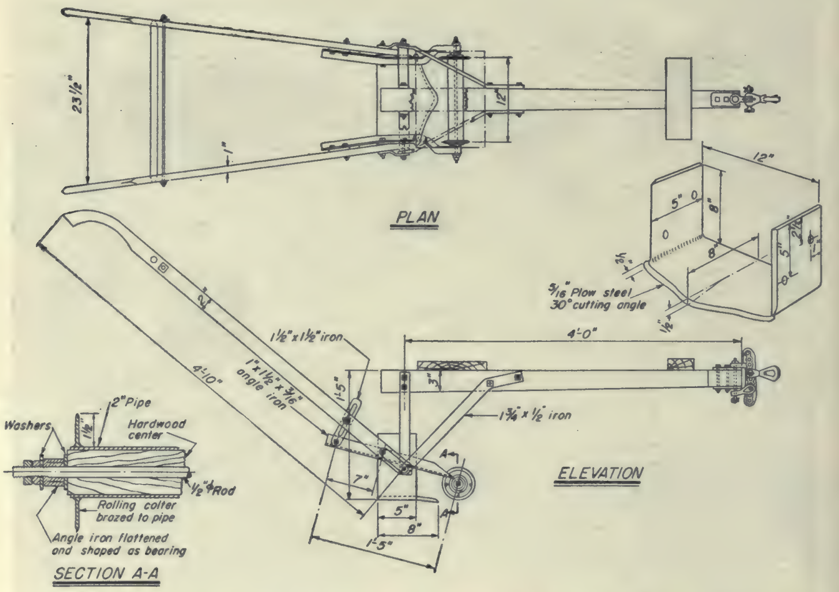

23½"
1"
12"
3
PLAN
12"
5"
8"
8"
2½"
5"
1"
3½"
5/16" Plow steel 30° cutting angle
½"
2"
1½" x 1½" iron
4'-0"
1" x 1½" x 3/16" angle iron
4'-10"
1'-5"
3"
1¾" x ½" iron
A
A
7"
5"
8"
1'-5"
ELEVATION
2" Pipe
Washers
1½"
Hardwood center
½" ɸ Rod
Rolling colter brazed to pipe
Angle iron flattened and shaped as bearing
SECTION A-A

FIGURE 22.—A home-made walking-plow type of sod cutter. Properly constructed cutters of this type have given particularly good results in harvesting bluegrass sod.

ıd eliminate the danger of cracking, reinforced concrete is often referable for the apron slab and cut-off walls regardless of the kind f material used in the rest of the structure. The apron slab should ave a minimum thickness of 5 inches for dams up to 2 feet high. ı dams more than 2 feet high this minimum thickness should be ıcreased about 1 inch for each 2 feet or fraction of a foot of additional height. As far as possible, each structure should be built as unit so that in the event of partial failure arising from a wash-out round the end the structure itself will not fail and can be repaired y the replacement of earth around the washed-out parts.

Some general specifications for the construction of small masonry ıeck dams and their location with respect to channel and terraces re shown in figure 23. The specifications apply only to the smaller ype of structures. If structures higher than 4 to 5 feet are required, is advisable to have separate plans and specifications prepared by competent engineer. In ordinary work these higher structures are sually not required. Satisfactory structural protection can often provided for a high overfall by the use of two or more low strucıres. In order to reduce the possibility of the structure failing ecause of wash-outs, care should be taken to provide ample notch ıpacity for the contributing drainage area (table 3), impervious oundations, and hindrances to seepage around the structure. Cutf walls should extend well into the bottom and sides of the channel xcavation, and an impervious type of soil should be firmly tamped round the structure. Particular care should be taken to see that ead-wall extensions go far enough into the soil to provide adequate rotection even after the side of the ditches slough off to a natural ıgle of repose. On colloidal soils, such as the Texas blackland, hich tend to crack and shrink away from structure walls during ry periods, further precautions must be taken in order to minimize ash-outs. In soils of this type it has been found advantageous to ix a good portion of sand or manure (usually sand) with the earth ıat is used to backfill around the structure and then protect the ırface with a good sod cover. All earth fills, backfills, or slopes ıbject to washing should be protected with vegetation.

Outlets that are to be protected by structures should be excavated accommodate the structures and the amount of run-off to be hanled. Although it is not always necessary to excavate outlet chanels fully where structural protection is to be provided it is usually esirable to do so wherever convenient so the sides can be sloped, erms leveled off, and some vegetation established thereon. In some ıannel outlets only a minimum amount of excavation is required open up the channel, and the remainder of the earth is washed ıt of the channel by subsequent run-off. Plowing between rains very helpful in hastening this process. Structure locations must excavated at least to the outside dimensions of the structures, and the masonry cannot be poured directly against the earth, additional xcavation is usually required in order to provide adequate working pace around the structure. Most of the channel can be excavated ith graders or scrapers, and "step cutting" of the channel with rapers at the location of the structure will often reduce much of ıe hand labor required for the excavation. Step cutting is the

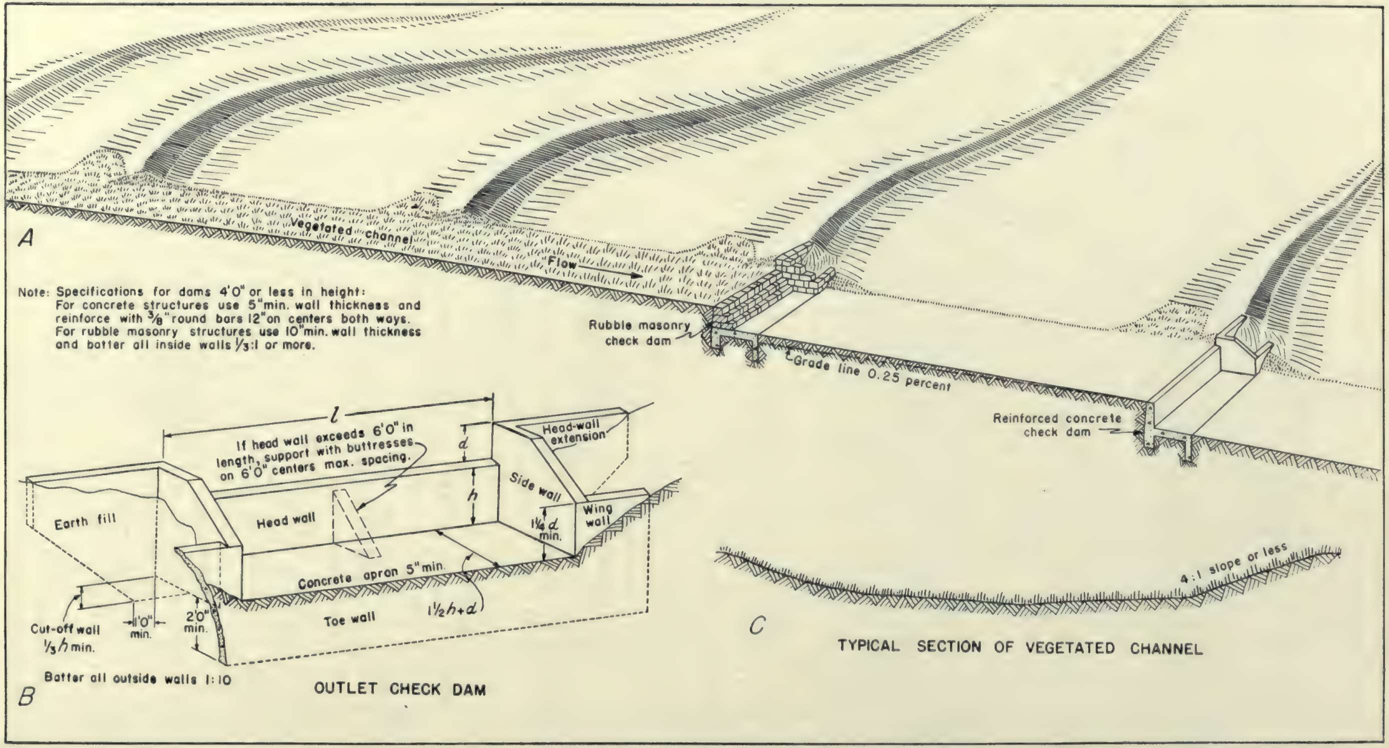

A
Vegetated channel
Flow
Rubble masonry check dam
Grade line 0.25 percent
Reinforced concrete check dam
Note: Specifications for dams 4'0" or less in height:
For concrete structures use 5" min. wall thickness and reinforce with 3/8" round bars 12" on centers both ways.
For rubble masonry structures use 10" min. wall thickness and batter all inside walls 1/3:1 or more.
l
If head wall exceeds 6'0" in length, support with buttresses on 6'0" centers max. spacing.
d
h
Head-wall extension
Side wall
Wing wall
1¼ d min.
Earth fill
Head wall
Concrete apron 5" min.
Toe wall
1½h+d
Cut-off wall 1/3 h min.
1'0" min.
2'0" min.
Batter all outside walls 1:10
B
OUTLET CHECK DAM
C
4:1 slope or less
TYPICAL SECTION OF VEGETATED CHANNEL

FIGURE 23.—A terrace-outlet channel that is protected from erosion by a combination of vegetation and mechanical structures: *A*, A sectional view, which shows vegetative protection in the upper reaches of the channel and check dams in the lower part; *B*, construction details of the check dams; *C*, cross section of the grassed channel.

excavation of a drop across the channel at the location of the structure.

The weir notch of terrace-outlet structures should seldom be less than 18 inches deep, and the elevation of the weir crest should be at east 1 to 2 inches below the channel elevation at the terrace outlet. This drop provides some allowance for rough construction practices and avoids the possibility of restricted terrace drainage as a result of the crest's being finished higher than the bottom of the errace channel. If the volume of run-off over the terrace-outlet structure is large it may be desirable to deepen the notch in order to avoid excessive widths, but extreme care must be exercised to protect he drop from the elevation of the terrace channel to that of the weir crest and prevent overfalls from advancing up the terrace channel. This drop should be sloped and sodded.

A grade of 0.25 percent from the weir crest of the lower dam to he bottom of the apron slab of the dam immediately above will usually provide stable channels between structures. Since the top of the apron slab should never be constructed to a higher elevation han the bottom of the channel, the actual grade in the channel will be from the top of the apron slab to the weir crest of the lower structure. Determining channel gradients in this manner has the effect of increasing the actual grade considerably if structures are close together and reducing it if they are more widely separated. Since the channel velocity is largely dissipated at each structure and close spacing of structures does not permit the velocity to accelerate for any great length of time, it is believed that the slightly steeper grade for short distances will usually be safe. In some localities where soils are very erodible a level gradient from the top of the apron on one dam to the weir notch on the dam immediately below is necessary. Care must also be exercised to assure a stabilized grade below he last structure in an outlet channel. Too steep a gradient below structures leads to the development of overfalls, which ultimately undermine or endanger the structure.

The alinement of outlet structures with respect to the terraces should not be overlooked in planning a terrace system in which mechanically protected outlets are to be used. The outlet structures should be located and connected with the terrace so that the head-wall extension projects into the terrace ridge. If a central outlet channel is used, into which terraces enter from both sides, the erraces on opposite sides should approach the channel directly opposite each other, so that the one outlet structure will serve both terraces. This practice gives a systematic appearance with any type of collective outlet. It is not essential, however, in vegetated channels. In order to reduce the amount of excavation for the structure or to permit a straighter approach of the terrace to the outlet it is often advisable to locate the structure downhill as much as 1 foot in vertical elevation from the ordinary location. The last section of the terrace is also moved downhill in a manner similar to hat described under Alinement of Terraces and Outlets (p. 26). Even though the terrace and outlet structure are moved downhill, same weir-crest elevation and terrace-channel grade are maintained.

It is usually advisable to use only one outlet structure for each errace interval. On the steeper slopes it may sometimes be neces-

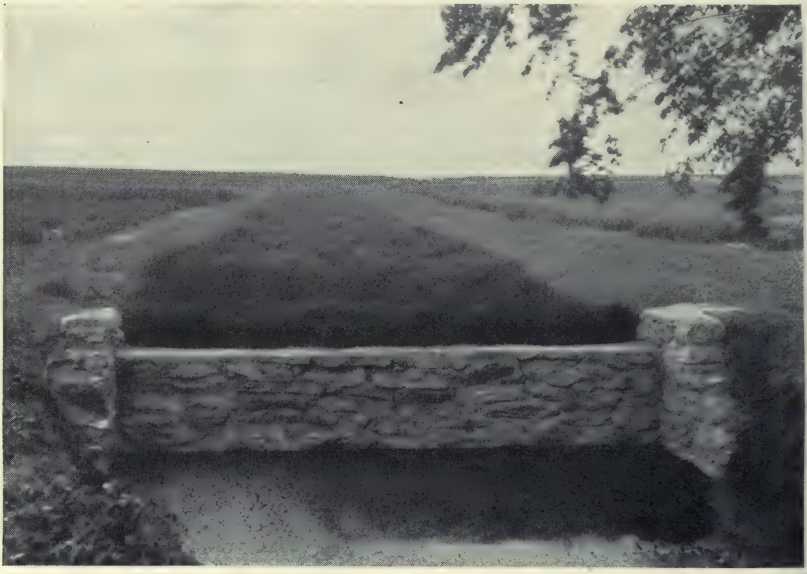


FIGURE 24.—A masonry structure has been used at the lower end of the channel to carry the run-off over a critical overfall to a stabilized drainageway.

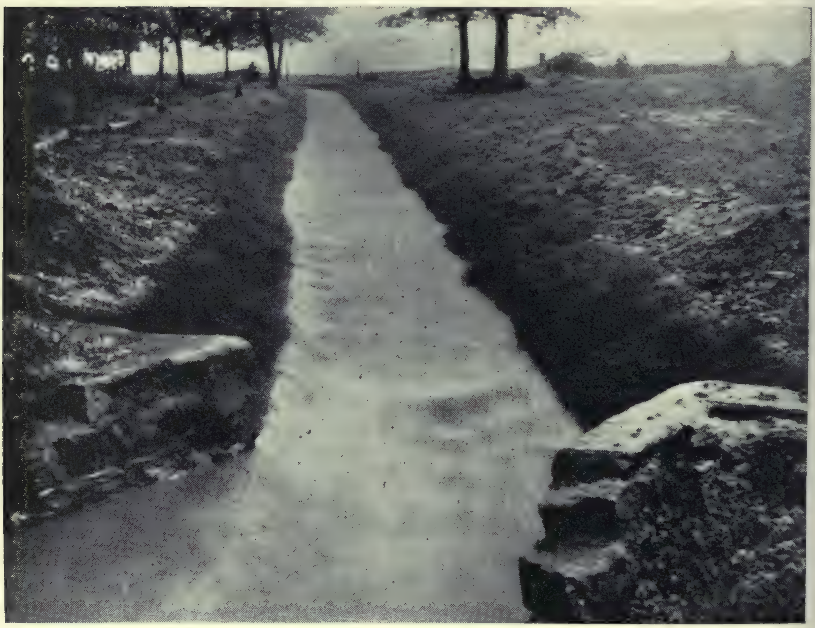


FIGURE 25.—This is the type of structure most commonly used if structural protection is necessary in farm drainageways.

sary to use two structures for each terrace interval, in which case the second structure is usually located midway between the terraces. Structures at bends in structurally protected channels should be located so that they will discharge the run-off parallel to the direction of the channel below the structure. With this procedure some riprapping or protection of the channel side by sodding may be necessary immediately above the structures, but the turbulence and danger of undercutting below the structures will usually be reduced to a minimum. Figures 24 and 25 show masonry structures at critical points in an outlet channel.

If run-off water must be conveyed over steep slopes it may sometimes be necessary to resort to high-velocity channels or continuous flumes (fig. 7). Structures of this type will usually have a very limited use, and capacity computations and design specifications should be made by a competent engineer. The steep slopes produce such high channel velocities that a comparatively small cross-sectional area usually permits a high rate of run-off disposal. Besides providing ample cut-off walls to prevent excessive seepage between the earth and channel lining, an apron or stilling basin must be provided at the end of the flume to dissipate the run-off velocity safely. A long, spreading type of apron may be used, or sufficient outlet protection can sometimes be provided by continuing the flume several feet below the water elevation in an adjacent stream.

MAINTENANCE

The development of satisfactory drainageways and outlets usually requires considerable attention, patience, and ingenuity. The methods and materials used, the soil and rainfall conditions, and the season of the year at which the work is done all have a marked influence on the success attained. Discouraging results are frequently experienced when high-intensity rains or periods of severe drought follow the installation of the initial structures or the planting operations. An attempt may even result in complete failure the first time, but produce satisfactory results when repeated. If necessary precautions are taken and the work conducted in a systematic and thorough manner, the results will usually be satisfactory. After an adequate water-disposal system has been established for a farm it cannot be considered permanent and thereafter neglected (fig. 26). Systematic inspection, repair, and maintenance must be carried out year after year in order to assure proper run-off disposal and adequate protection of the drainageways.

New drainageways and outlets should be inspected periodically. Especially after heavy rains they should be examined to determine whether they are functioning properly or need minor repairs. This is particularly true in drainageways and outlets in which the grasses are not fully established. Some minor adjustment or repair during this period may often prevent failure in establishing the cover. Damaged sod or washed-out seed should be replaced immediately, and any other condition that appears unsatisfactory or undesirable should be corrected. Mechanical structures are also more subject to failure when first installed because it usually takes a year or so for them to

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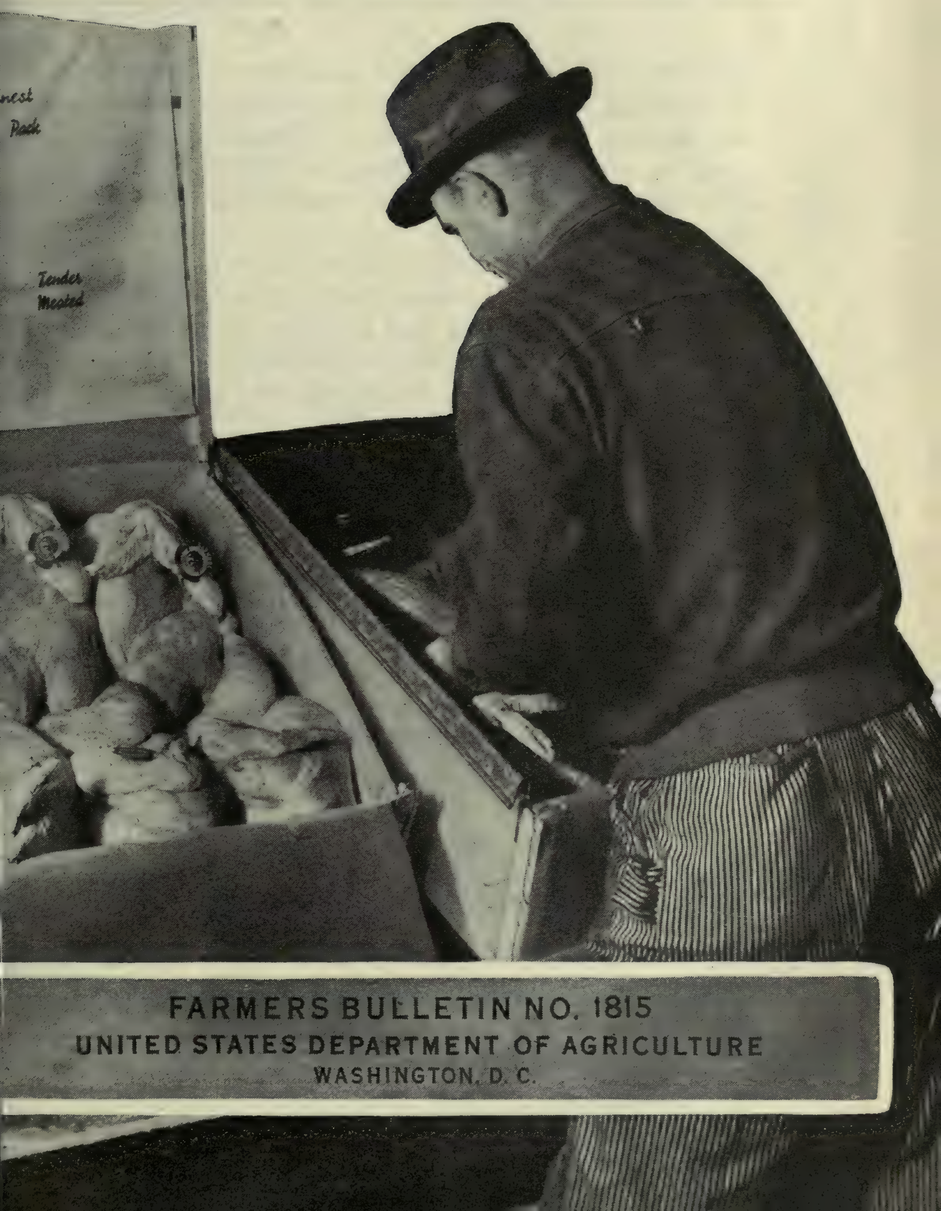
GRADING DRESSED TURKEYS


nest
Pack
Tender
Meated

FARMERS BULLETIN NO. 1815
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

FROM THE PRODUCER'S standpoint, the correct grading of turkeys is a very important factor in the success of his enterprise. Without dependable grading, successful marketing is practically impossible, and without successful marketing, little profit may be expected.

Whether the producer grades his own turkeys or has this done by a licensed grader, a familiarity with the grade descriptions and how the grades are applied will create a mutual understanding and be a source of satisfaction to producers, graders, and buyers.

How to grade according to Government standards can be learned by any producer who makes a thorough study of the grade factors involved. This bulletin attempts to point out by description and illustration the most important of these factors.

Washington, D. C. **Issued September 1938**

GRADING DRESSED TURKEYS

By Thomas W. Heitz, *marketing specialist, Bureau of Agricultural Economics*

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IMPORTANCE OF CAREFUL GRADING

THE MARKETING of poultry is highly competitive in the terminal wholesale markets. There is always a demand for turkeys of good quality, but stock of poor quality is sold to the less discriminating trade at lower prices. The "straight-run" pack of turkeys is no longer in demand, for buyers are coming more and more to require uniform and careful grading.

Even turkeys of good quality have little sales appeal unless the birds are carefully graded and packed. Some buyers want only small turkeys, some want medium-sized, and others want the heaviest that can be obtained. Some prefer hens; others, young toms. Some want only the highest quality obtainable, whereas a few want medium-priced or low-priced stock.

To satisfy these varying demands, the careful packer should grade his turkeys strictly in accordance with definite standardized grades, so that a buyer who wants a number of turkeys of a certain weight and grade will not be obliged to buy several boxes or barrels in order to get what he needs. A few birds of second or third grade in a box or barrel of fine turkeys are likely to reduce the price of the entire pack. Careful grading and correct methods of packing usually enable the producer or shipper to establish a reputation for his produce, which is reflected in an increased demand for it and in larger profits for him.

ADVANTAGES OF USING GOVERNMENT STANDARDS FOR DRESSED TURKEYS

The universal acceptance and the correct use of the grades in the Government standards for dressed turkeys, certified by graders supervised by the Government, should benefit producers, dealers, and consumers. It would assure the producer a just and uniform grading, making it possible for him to market his turkeys on a basis commensurate with their quality. The producer of high-quality turkeys should receive an adequate price and should not be penalized by the lower price paid to the producer of poor quality as often occurs when turkeys are bought on a straight or ungraded basis, for when the buyer purchases an ungraded lot he must make enough on the better birds to offset his losses on the undergrades.

When turkeys are sold subject to grading by the buyer, the producer is at a loss to know how the buyer will grade them. When the crop is short or a rising market appears probable, there is a tendency for most buyers to grade freely in order to place as many turkeys as possible in the top grade. When the market is declining, commercial grading is usually rigid, and many turkeys that should be placed in the top grade are placed in a lower grade.

The Government standards, on the other hand, remain unchanged at all times regardless of market conditions or seasons, and the Government grades are so supervised that the producers are assured of uniform grading when the Government standards are used (p. 3). Since the grading work was begun, under Government supervision, the quantity of dressed turkeys graded has increased each year. Approximately 30,000,000 pounds are now graded annually.

A notable result of the grading program has been the improvement in the quality of the birds offered for sale by producers who have sold their turkeys under this system of grading for several seasons. Almost without exception, the percentage of those that qualified for the top grades has increased each year. In some States where barely half the crop was in the U. S. Prime grade at the beginning, the percentage of birds of U. S. Prime grade has increased to between 70 and 80 percent, and it is not unusual now in some States for more than 90 percent of the turkeys sold by grade to be U. S. Prime.

The advantages of uniform grading according to uniform standards are almost as great for the country packer and shipper and the city dealer as for the producer. Under the usual commercial conditions the terminal-market receiver is handicapped in buying turkeys because he is seldom certain of the quality being offered, especially when he buys at country shipping points that are too distant to permit personal inspection. The producer's or shipper's idea of a "fancy" or a "choice" turkey may not conform to the idea of the receiver or buyer. Commercial ideas of grading differ in different sections of the country, sometimes among different packers in the same section. In some markets, it may happen that no two packs of turkeys received have been graded according to the same standards.

If Government standards and uniform methods of grading and packing were generally adopted, buyers would have more confidence when making their purchases, and producers and shippers, knowing their product would be graded by a qualified disinterested grader, would have less hesitancy in offering their turkeys for sale on a graded basis.

When disputes arise between buyer and seller, the producer, as well as the receiver, has recourse to an official regrading of the turkeys at terminal markets as part of the United States grading service. This regrading service has saved producers thousands of dollars and has safeguarded the receivers, who are often required to pay for car-lot shipments of turkeys before they are unloaded.

From the standpoint of the consumer, a tag that gives the correct grade is a valuable guide in the selection of a turkey. The producer should always bear in mind that it is the consumer's willingness or ability to pay that finally decides the price the producer will receive. Therefore, consumers must be satisfied if turkey production is to be profitable. The best way to satisfy consumers is to make sure that each one always gets the grade of turkey she pays for.

The average housewife buys a turkey only once or twice a year and usually is not so well informed regarding the factors that make for quality in a dressed turkey as she is regarding other meat products. Consequently she feels more confidence in her selection if the bird is labeled with a tag that shows its real grade.

UNITED STATES STANDARDS FOR DRESSED TURKEYS

The United States standards for dressed turkeys provide for both classes and grades. Besides this, certain other factors are to be given consideration when classing and grading are being done. The standards have been tested under actual operation for 10 years, and slight revisions have been made from time to time in the light of actual experience.

UNITED STATES CLASSES FOR DRESSED TURKEYS

The United States standards for dressed turkeys provide four classes: Young Hens, Old Hens, Young Toms, and Old Toms.

SCHEDULE OF CLASSES, SUBCLASSES, AND GRADES FOR DRESSED TURKEYS

Age and sex classification	Dressing and packing classification	Grades
Young Hens Subclass: Yearling Hens. Young Toms Subclass: Staggy Toms. Old Hens Old Toms	Plucking: Scalded Semi-scalded Dry plucked Dressing: Drawn Undrawn Finish: Milk-fed Grain-fed Chilling: Fresh dressed Fresh hard chilled Storage Packing: Dry Iced	U. S. Special, or U. S. Grade AA. U. S. Prime, or U. S. Grade A. U. S. Choice, or U. S. Grade B. U. S. Commercial, or U. S. Grade C.

These four classes are necessary because different values are attached to the respective grades. The young birds are always worth more than the old; certain classes of trade prefer hens; others prefer toms. For the preseason or postholiday trade, the large toms are usually most in demand, for at those seasons most of the turkeys are used by restaurants and hotels, which prefer large birds. For the Thanksgiving and Christmas trade the hens and small young toms are usually in most demand as most of the turkeys for the holiday trade are retailed for family use.

Young birds can be detected by the appearance of the flesh and by the flexibility of the breastbone. The flesh of the young bird is fine-grained and soft, whereas that of an old turkey is coarse, somewhat darkened, and tough. The tenderness of the flesh can be determined by pressing the flesh of the breast between the ends of the thumb and forefinger. If the bird is young, the flesh can be easily penetrated, and the thumb and finger will easily press through to the breastbone. If the flesh is hard and "rubbery" it is an indication of greater age, and more roasting will be required to make it tender.

The end of the keel bone of the young turkey is composed of cartilage and is soft and flexible. By feeling of this bone the age of the turkey can be easily ascertained. If the turkey is young the end of the bone or cartilage should be flexible—should move easily back and forth. If the bone is hard and rigid so that it cannot be moved, the cartilage has hardened into bone, and the turkey is classed as Old.

Further indications of age are evidenced by the appearance of the skin. Old turkeys usually have a coarse skin, and unless they are very fat the skin is loose and flabby, whereas the skin of the young turkey adheres more closely to the flesh and is soft and velvety. Feather follicles in the skin of the old birds are deeper and farther apart, giving the skin a rough, uneven appearance.

CLASSIFYING YEARLING HENS AND STAGGY TOMS

It is not difficult to differentiate between a very old turkey and a very young one, but there are many turkeys of intermediate age, such as yearling hens and staggy toms, that may be difficult to classify. Usually a turkey is classed as Young until it reaches 1 year of age, but this is not always the case. The breastbone of a young hen nearing 1 year in age is usually rather rigid, and the flesh begins to take on the characteristics of an old hen. Breeding and laying have a tendency to harden the flesh of the hen turkey; and while it is true that many young hens begin laying at 5 or 6 months of age and are still soft-meated, the characteristics of an old hen soon show after the laying season begins. Hens that have been laying have a greater width between the pelvic bones, and the vent is moist and somewhat enlarged. Where these conditions are apparent the usual practice is to classify the turkey as Old, especially if the keel bone has become somewhat rigid and the flesh is coarse and darkened. Where the turkey appears to have tender flesh, even though the keel bone is only slightly flexible, the bird is classified as Young. Usually a hen turkey will not take on excessive fat until the second year. When such fat appears, it is a fairly good indication that the turkey should not be classed as Young.

The correct classification of a young tom nearing maturity is ighly important, because the age of a young tom, unlike the age f a young hen, is an important factor in the grading of the bird. or example, a hen nearing maturity may be classed as Old or oung without the grade being affected, but a young tom nearing aturity is usually classed as Young but is not permitted in the rades above U. S. Choice. One of the first indications of approachng maturity is spur development. Spurs appear as little knobs on he legs long before the flesh has become hardened and are not always n indication of age. A young tom should never be graded down n account of spur development alone. Rather the appearance of purs indicates that a close examination of the bird is desirable. s long as the meat is soft and fine-grained and the keel bone is lexible the turkey should be classed as Young. As a young tom evelops, the skin of the breast becomes soft and flabby, and, as evelopment further progresses, it becomes badly puffed and pouchy. fter this condition develops, the turkey may still be classed as oung if the meat is still somewhat softened, but the turkey should ot be graded higher than U. S. Choice. If the breast is only somehat softened and not puffed, the turkey may be graded as U. S. Prime.

Occasionally a turkey is found in which sexual development is uch that classifying it is difficult. The body may be long and angy and have the appearance of that of a young tom, while the ead may be fine-cut and narrow, as characteristic of a young hen. y an examination of the vent of such birds, as is done in sexing aby chicks, the true sex can usually be determined. It is usually est to place such a turkey in the class to which its body most conorms, so that the appearance of the pack will not be spoiled by a ack of uniformity of body shape.

SUPPLEMENTAL CLASSIFICATION FOR TURKEYS

Other conditions, which relate to plucking, dressing, finish, degree f chilling, and packing, make it necessary to establish further lassifications.

Plucking.—Three methods of plucking the feathers from turkeys re used: The full-scald, the semiscald, and the dry-picked. Each f these methods has a direct bearing on the appearance and keeping uality of the turkeys. Therefore, in classifying and grading dressed urkeys the method by which the carcasses have been plucked should e taken into consideration.

The full-scald method is used mostly when producers dress and arket their turkeys locally. The carcass is immersed in water eated to a temperature of from 170° to 180° F. The hot water pens the skin pores, makes the skin very tender, and lowers the eeping quality of the bird. The effects of full scalding are so amaging to the skin, that turkeys which have been plucked by this ethod are not permitted in the grades U. S. Special and U. S. Prime.

The semiscalded method is used chiefly by dressers at country packng plants. The carcass is immersed for about 30 seconds in water eated to a temperature of from 125° to 128° F. For satisfactory esults the temperature of the water must be within this range. An perator should not attempt to use this method unless he is properly quipped and has acquired a knowledge of its operation through an experienced workman. The method has many advantages over fu scalding and dry picking. The skin is not injured, and resultin conditions are such that the pinfeathers are readily removed.

The dry-picking method of plucking is used by both produce and packers who ship to distant markets, and in most sections of th country turkeys are dry-plucked for the local markets. No water used. The feathers are loosened by piercing the lobe of the bra which controls the feather muscles. The producer who dresses h own turkeys will find this method of plucking the most satisfacto and should not attempt any other method without the advice of skilled operator.

Dressing.—Dressed turkeys are marketed either drawn or u drawn. At present nearly all are marketed undrawn, that is, th head, feet, and entrails are not removed. During the last few yea a considerable quantity of other classes of poultry—mostly chicke and fowl—have been marketed drawn, and some turkeys are no so marketed. If this form of dressing proves as desirable as no seems possible, it will be only a matter of time before full-draw turkeys will be very usual on the market. When full-drawn Go ernment-graded turkeys are graded, the same specifications are us as for undrawn. Drawn turkeys that are not Government inspect cannot, under the Government regulations, be subsequently Gover ment graded.

Finish.—The kind and quality of feed received by turkeys has important bearing on the quality of the meat. The United Stat standards recognize two kinds of finish—milk-fed and grain-fe Some markets prefer milk-fed turkeys; others prefer grain-fed.

Milk-fed turkeys have bleached skin and flesh; the skin has a so velvety appearance and is very light in color; the muscle fiber softened by fatty deposits throughout the connective tissue.

Grain-fed turkeys do not show any marked evidence of milk fee ing and usually have a cream-colored or yellow appearance. Unle the skin is fully bleached, the turkey should not be classed as milk-f but should be included in the class of grain-fed.

Chilling.—Turkeys may be marketed as fresh-dressed, fresh har chilled, or storage stock. The chilling condition of turkeys shou be taken into consideration when they are graded. Fresh-dress turkeys are those that have not been either hard-chilled or har frozen. Fresh hard-chilled turkeys are those that have been har chilled but not frozen long enough to develop the appearance cold-storage stock; they must not have been held in storage mo than 60 days. Storage turkeys are those that have been held at low temperature for 60 days or more or show evidence of deteriorati from freezing regardless of the length of time held. The most notic able effects of storage on poultry are dryness of skin and loss body bloom. Dry, scaly spots, known as "freezer burn," may also present on the surface of the skin, and the eyes may be shrunk and discolored. The blood around the cavity of the mouth or whe the bleeding cut was made is dark brown in color instead of r and usually has an unpleasant odor.

Packing.—Two refrigerating mediums are used to keep the turke in good condition during transit to market. One is ice, and th other is cold air. Dressed turkeys that have been packed in ice a known as ice-packed; those that have been subjected to cold air a nown as dry-packed. Because the contact of ice with the carcasses ; injurious to their keeping quality and to the appearance of the kin, dressed turkeys that have been refrigerated by this method re not permitted in the U. S. Special and U. S. Prime grades. When ry packing is used, the air is cooled by ice or by mechanical refriger-tion; the turkeys are kept dry and do not come in direct contact ith the ice.

UNITED STATES GRADES FOR DRESSED TURKEYS

The United States standards provide four grades for the dressed urkeys in each of the four classes: U. S. Special or U. S. Grade AA, . S. Prime or U. S. Grade A, U. S. Choice or U. S. Grade B, and . S. Commercial or U. S. Grade C.

U. S. Special or U. S. Grade AA is the highest grade. To be laced in this grade, a carcass must be a commercially perfect speci-ıen of any of the four classes of dressed turkeys. The requirements or this grade are high; only a very small proportion of the turkey rop will qualify for it. Birds of this grade are found mostly in ıe output of commercial producers who employ careful feeding and anagement methods. Dealers and packers who buy from producers iscellaneous lots of dressed turkeys, after they have been shipped considerable distance, packed and refrigerated, are not likely to nd any carcasses that qualify for this grade. The few turkeys of ıis quality that are received in such lots can usually be packed best advantage with those of the U. S. Prime grade for it is not orth while to segregate them into a separate pack.

U. S. Prime, or U. S. Grade A, is the grade that represents the econd-highest quality according to the United States standards. ı the markets it is commercially considered as "top" quality because is the highest grade obtainable in commercial quantities.

Most of the birds on the markets grade U. S. Choice, or U. S. rade B. These turkeys are considered commercially to be of very ıir quality and usually command a price that is within 2 or 3 cents pound of the price received for turkeys of the U. S. Prime grade.

U. S. Commercial, or U. S. Grade C, is the lowest grade. Any dible turkey may be included in this grade except those that are xcluded by the detailed descriptions for this grade.

QUALITY DESCRIPTIONS OF THE INDIVIDUAL GRADES

U. S. Special grade, or U. S. Grade AA.—The first thing to con-der in deciding whether a turkey is of high enough quality to rade U. S. Special is the quantity of flesh on the carcass. The grade . S. Special calls for a full-fleshed bird. This means that the car-ıss must have a broad, full-meated breast and that the back and ll bones must be fully covered with fat. The meat of the breast ıould be even with the breastbone and flat across the top rather ıan pointed. Turkeys that are full-fleshed have very little of the ıaracteristic dark meat showing through the skin. Turkeys of the ıale sex have narrower breasts than those of the female sex; there-ore, a U. S. Special tom turkey would have a breast full-fleshed only ı accordance with the characteristics of the sex.

In the case of either young hens or toms, the flesh of the bird must e soft, fine-grained, and tender and have a translucent appearance.

This is usually true of all young birds that have been properly fed. But if young birds have been allowed to run at large, the constant exercise in search of food hardens the muscle fiber and makes the bird coarse and hard-fleshed, which causes the carcass to be placed in a grade below U. S. Special.

Turkeys that grade U. S. Special must be especially well dressed. The feathers must be completely removed from the carcass, and all noticeable pinfeathers must be removed. The butts, heads, and feet must be clean. There must be no feed in the crop that can be detected by feeling or by sight, for any kind of feed is likely to ferment and sour the flesh of the bird. Very slight skin abrasions are permitted if they are not on the breast. There must be no tears in the skin, and even slight discolorations and skin bruises are not allowed on the breast. No flesh bruises are permitted on any part of the carcass. A flesh bruise may be distinguished from a skin bruise by moving the skin from side to side. A skin bruise is a blood clot attached to the underskin and will move as the skin is moved. If the blood clot is stationary and does not move with the skin the bruise is a flesh bruise and is not permitted in the U. S. Special grade, even if it occurs on the wing tip or on the back.

A dented breastbone is usually spoken of as a notched breast and is not to be confused with a crooked breast. If the dent is not more than one-eighth of an inch in depth it is not a disqualification for this grade. The depth of the dent can be measured by placing a straight piece of cardboard or a straightedge along the top of the breast and then with a rule measuring the depth of the depression.

Crooked breastbones or other deformities, such as swollen joints or crooked backs, are causes for disqualification in the grade of U. S. Special. No broken bones, open tears, or sewed skin are permitted.

Because of the poor appearance of scalded and ice-packed turkeys and because their keeping qualities are not as satisfactory as dry-picked and dry-packed birds, they are not graded as U. S. Special even though they would otherwise qualify for that grade. (Fig. 1, *A*.)

U. S. Prime grade, or U. S. Grade A.—Turkeys that are well-fleshed but not necessarily full-fleshed are included in the U. S Prime grade—also those that are full-fleshed but have dressing defects that are permitted in the U. S. Prime grade but not in the U. S. Special grade, are included. The young birds must be soft-meated and tender. They must be well-fleshed throughout, with back, hips and bones well-covered with fat. The hip fat and the breast fat must be connected with fatty tissue over the abdominal region. The bleeding requirements are almost as strict for the U. S Prime as for the U. S. Special grade. More pinfeathers may be permitted, especially if scattered over different parts of the carcass other than on the breast. The breast must be practically free from pinfeathers, and, as in the case of U. S. Special, there must be no feed in the crops.

Slightly discolored skin or small skin bruises and abrasions do not disqualify a carcass for this grade unless they are on the breast. Small flesh bruises may be included if they are not over one-half of an inch in diameter and are not on a heavily fleshed part of the carcass. In this grade the dent in the breast may not exceed one-fourth of an inch in depth, in contrast to one-eighth of an inch in the U. S. Special grade. A crooked breast bone is not permitted, and if the bone is so curved that it will interfere with the slicing of the meat, the turkey must be placed in a lower grade. No deformities

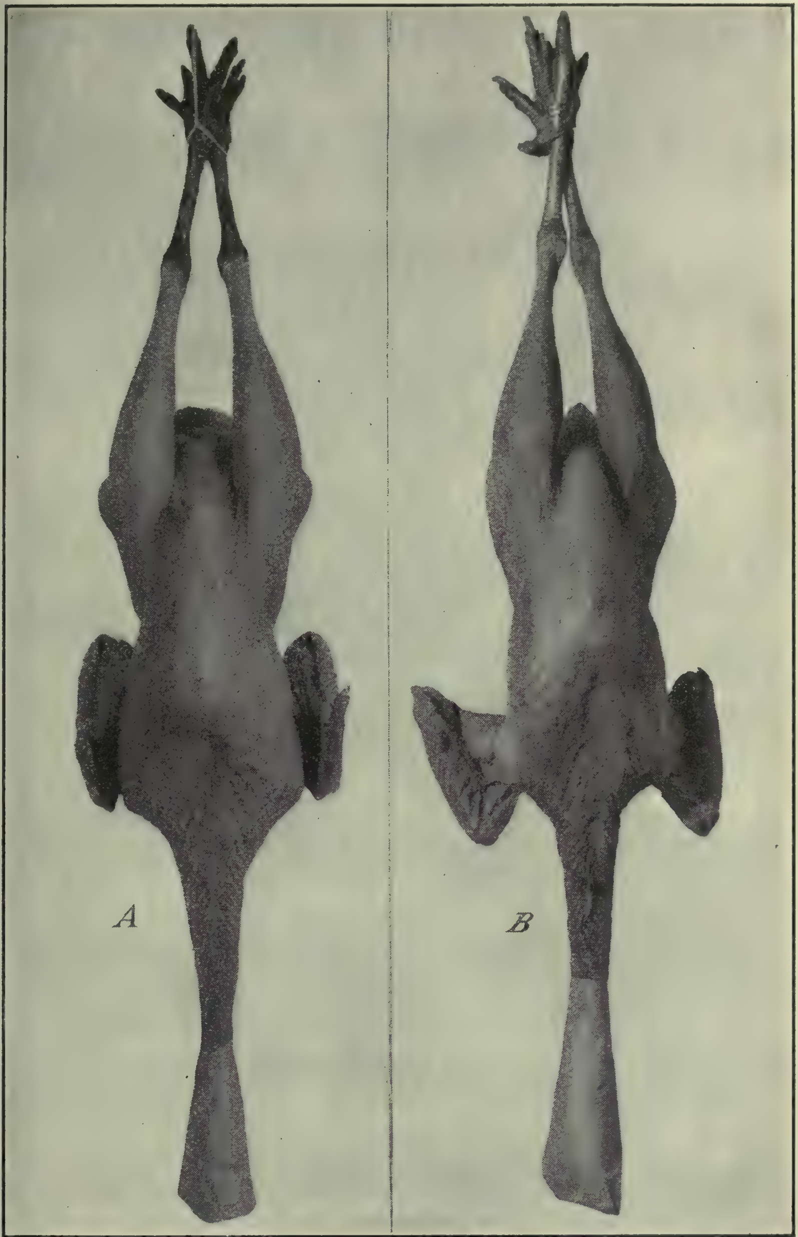


FIGURE 1.—Special and Prime grades of turkey. *A*, U. S. Special, or U. S. Grade AA, young hen turkey. The breast is broad and full, the hips are well rounded, and the entire carcass is fully covered with fat. *B*, U. S. Prime, or U. S. Grade A, young hen turkey. This turkey is well-fleshed but somewhat narrow over the hips. The carcass is well covered with fat.

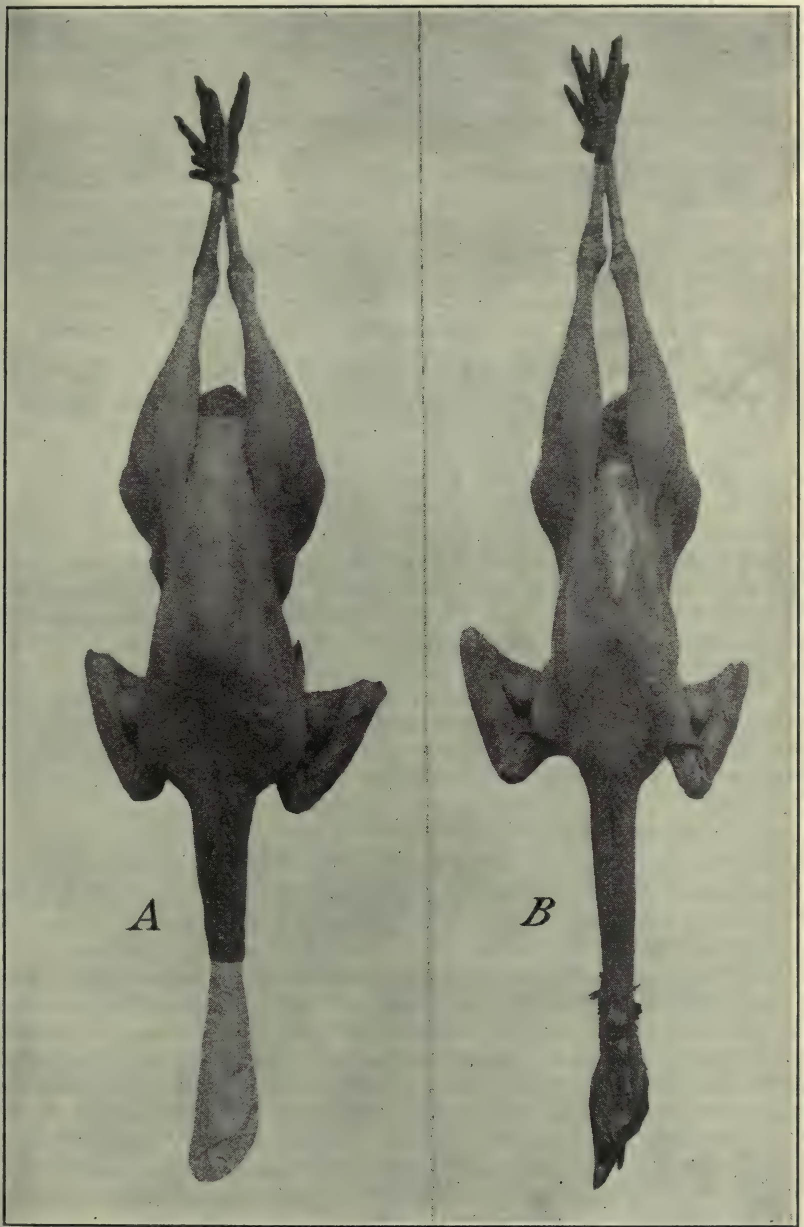
of any kind are permitted. Wings broken above the wing tip or broken legs are not permitted. One disjointed leg or wing is permitted if it is not bruised at the joint. If the crop is properly removed (that is, if the entire crop is taken out through an incision in the rear and above the wing and the incision is properly sewed up) the bird is not barred from the U. S. Prime grade if it meets the other necessary qualifications. No open tears in the skin are permitted on any part of the carcass. No sewed tears are permitted on the breast. Dressing requirements are the same as for the U. S. Special grade; that is, the birds must be semiscalded or dry-picked and dry-packed. (Fig. 1, *B*.)

U. S. Choice grade, or U. S. Grade B.—A U. S. Choice turkey is one that is only fairly well fleshed and has no major defects. It may be fully fleshed, or it may be a well-fleshed bird that has such defects or deformities as to disqualify it from the higher grades but permitted in the U. S. Choice grade. There must be a considerable quantity of meat on the breast and other meaty portions of the carcass. The back, hips, and other bones must be fairly well covered with fat. Unlike turkeys in the two higher grades, it may show some evidence of poor bleeding and may have some scattered pinfeathers over the entire carcass. The grader should not confuse the terms "evidence of poor bleeding" with "poorly bled." Turkeys that have been poorly bled are placed below this grade. The crop must be empty. Slight flesh or skin bruises are permitted, but not more than three of them to each bird. In actual grading, "a slight bruise" should be construed to mean one not more than one-half of an inch in diameter. Slight skin abrasions or discolorations are permitted. No open tears in the skin are permitted that are more than 3 inches in length. Tears that have been properly sewed up may be permitted, even on the breast.

Dented or slightly crooked breastbones or other slight deformities such as misshapen wings or legs and crooked backs are permitted. One broken wing or one broken leg is permitted if the leg is broken below the hock or if the broken bone does not protrude into the flesh of the bird, or has not caused badly bruised flesh. Unlike the two higher grades, this grade requires no particular method of dressing—the birds may be scalded, semiscalded, or dry-picked, and either ice- or dry-packed. (Fig. 2, *A*.)

U. S. Commercial grade, or U. S. Grade C.—The U. S. Commercial grade is the lowest grade recognized in the United States standards. A turkey that does not meet this grade is considered unfit for shipment to market. A turkey of the U. S. Commercial grade may be poorly fleshed, and the back, hips, and bones may be poorly covered with fat. The breast may be very narrow providing little meat for slicing. No feed is permitted in the crop. Because of the absence of fatty tissue under the skin, the birds may have a dark-bluish appearance, the hipbones may protrude at the points, and the bones may be evident at other bony parts of the carcass.

This grade may also contain birds that are fleshed well enough for any of the three higher grades but have deformities or dressing defects that disqualify them from any of those grades. Poorly bled birds may be included in this grade, and birds that have numerous pinfeathers, which may be over the entire carcass. Flesh or skin bruises, abrasions, or discolorations are permitted, but not such as to make any appreciable quantity of the carcass inedible. In actual grading, this description would be construed to mean not over one-fourth of the carcass. Dented breastbones, crooked breasts, hunchbacks, and other deformities are allowed to some degree. But if the



IGURE 2.—Choice and Commercial grades of turkey. *A,* U. S. Choice, or U. S. Grade B, young hen turkey. The carcass is fairly well fleshed with a slight covering of fat over the sides and back. *B,* U. S. Commercial, or U. S. Grade C, young hen turkey. This turkey is poorly fleshed but is edible so far as can be judged by external appearance. Scarcely any fat shows through the skin covering of the carcass.

carcass has numerous defects or any severe deformity, the turkey must be at least fairly well-fleshed and of a higher grade otherwise than U. S. Commercial. Otherwise it is considered as below grade. Broken legs or wings, even if broken in the fleshy part of the bird, are permitted if they have not bruised the flesh so badly as to make more than one-fourth of the carcass inedible. Extremely emaciated birds, or birds showing evidence of disease such as to render the meat unwholesome, are barred from all of the U. S. grades. (Fig. 2, *B*.)

GENERAL RULES THAT APPLY TO ALL CLASSES AND GRADES

A few general requirements apply to all classes and grades of dressed turkeys. When turkeys do not meet these requirements, they are placed in a lower grade than their other characteristics would indicate, or they are thrown out of grade entirely. These general requirements relate to a number of conditions.

FREEZING

It is possible to hold turkeys a few weeks in storage under proper temperature without their deteriorating noticeably. When marks of freezing do not appear on the carcass or are not sufficient to affect the quality of the flesh, the grade of the carcass is not lowered, even though the carcass has been frozen.

Turkeys that show a dark, blistered, or dried skin caused by freezing cannot be placed in the grades U. S. Special and U. S. Prime. Usually when turkeys are held at a subfreezing temperature for 60 days or longer, the skin, after being thawed, loses its bright, fresh appearance or "bloom," and the meat has a darkened appearance. If this occurs, the grade of the turkey is lowered one grade. If the flesh shows marked effects of freezing, and if dry scaly spots appear over the entire carcass, the turkey is placed in the U. S. Commercial grade. For example a turkey may be of the U. S. Special grade when put into cold storage but may not be even of the U. S. Choice grade when it comes out of storage.

CLEANLINESS

A turkey that has a dirty carcass or dirty head, feet, or vent, cannot be placed in any of the U. S. grades. Dirt and filth are a cause of spoilage, and any condition that would tend to unwholesomeness throws the turkey out of grade. Clotted blood in the head turns sour rapidly and gives an offensive odor to the entire carcass. Feet that are caked with manure or dirt are full of contamination that will affect the meat of the carcass with which it comes in contact. Dirty vents may turn the surrounding meat green within a few hours. If the carcass is to meet any United States grade the feet and heads must always be washed, the vents squeezed out, and any condition that may make for unwholesomeness must be prevented.

PRECOOLING

Turkeys that have not been properly precooled, so that all animal heat is removed from the carcass before it is packed, are likely to deteriorate in quality and even become unfit for food. Graders must be equipped with thermometers for taking internal temperaures and must make sure that the turkeys, when packed, do not have n internal temperature higher than 36° F. A lower temperature han this is desirable, and if practicable the temperature should be educed to 34° before the turkey is packed.

In actual practice it may be necessary for the grader at times to grade turkeys before they have been sufficiently cooled, in order to avoid rehandling or the mixing of the producers' lots. When this is done, the grader must make sure the birds are properly precooled after they are graded. Unless the birds are sufficiently cooled beforehand, or will be cooled under supervision of the grader, it is not permissible to grade the birds in accordance with Government speciications.

FEED IN CROPS

An enormous loss is sustained by the turkey growers each year because of feed left in the crops. Feed in the crop not only spoils he appearance of the carcass but lowers its keeping quality. The feed ferments soon after the turkey is killed and gives off a sour odor which penetrates through the crop and causes the surrounding meat o turn sour. The skin over the crop often darkens and eventually urns dark green or black. Feed in the crop is not permitted in any of the United States grades. (Fig. 3.)

PICKING

Many turkeys are placed in a lower grade than they would be otherwise because of defects in picking. If turkeys are killed before hey are mature it is very difficult to remove all the pinfeathers even hough a great deal of time and care are given to removing them. The garters of feathers around the hock must always be removed, as well as all the tail, neck, and fan feathers. (Fig. 4.) Earlier speciications of United States standards permitted a single row of fan feathers on the wings but for several reasons it is now required that hey be removed. (The feathers are usually full of dirt and filth that nduce contamination and spoilage. Then if feathers are permitted n the pack, uniformity would not be possible unless they were of the same color. Added to this, the butcher is likely to chop off the wing ip, instead of pulling out the feathers, and this makes it difficult to keep the turkey in place in the roasting pan or on the serving platter.)

WHOLESOMENESS

It is emphasized again that dressed turkeys, when packed, should be free from any condition which may render them unwholesome as food. The condition and wholesomeness of the carcass are deermined largely by external appearances. Decomposition is first manifest in those parts of the carcass in which the viscera lies close o the surface of the skin. It is evidenced around the vent, between he keel and pelvic bones, and along the surface of the ribs. The meat first turns dark and then green. A condition of this kind is caused by decomposition from within and is usually the result of mproper precooling or failure to maintain a sufficiently low emperature.

The green appearance of the skin in off-condition turkeys is caused by intestinal putrefaction and the consequent production of hydrogen sulphite, which penetrates the thin body wall and acts upon the blood in the capillaries of the skin. Any evidence of this condition eliminates a carcass from any United States grade.

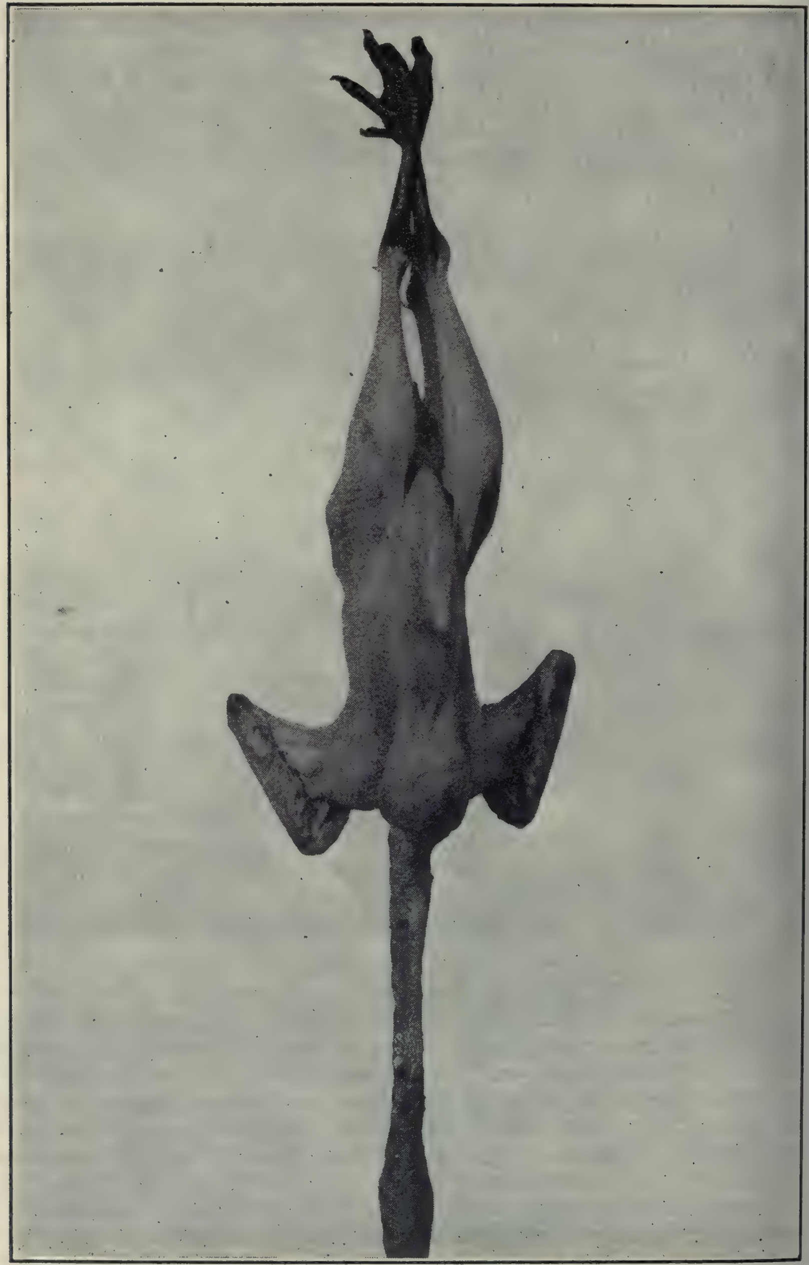
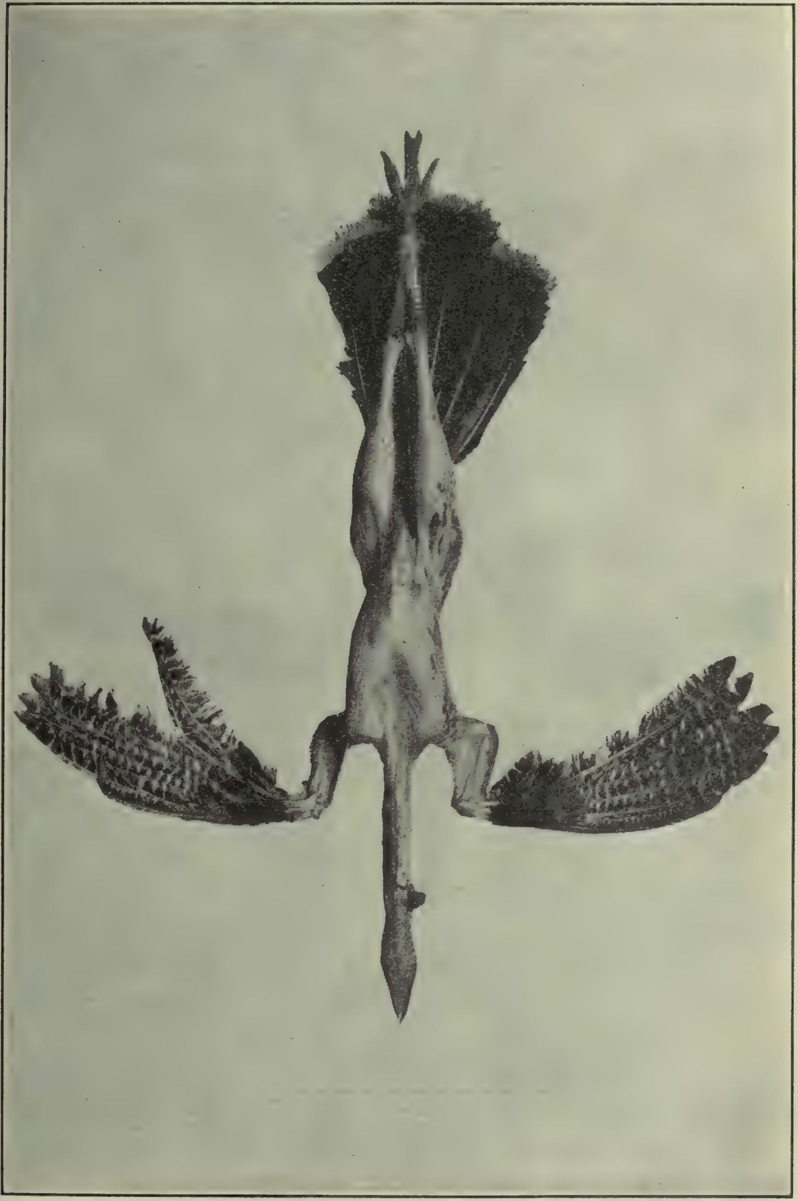


FIGURE 3.—A turkey with a full crop. Regardless of other conditions the grader is not permitted to place this turkey in any of the United States grades unless the crop is properly removed and the opening in the skin is sewed up.

Evidence of such diseased conditions as accompany tuberculosis r blackhead or tumorous growth is an indication of unwholesomeness. Turkeys so affected are barred from the United States grades.

EMACIATION

An extremely thin or emaciated turkey will not be placed in any nited States grade, for emaciation is an indication of a diseased



IGURE 4.—An improperly picked turkey. For sanitary reasons all feathers must be removed.

condition, and it is usually impossible to ascertain definitely whether or not a turkey is diseased unless it is eviscerated. (Fig. 5.)

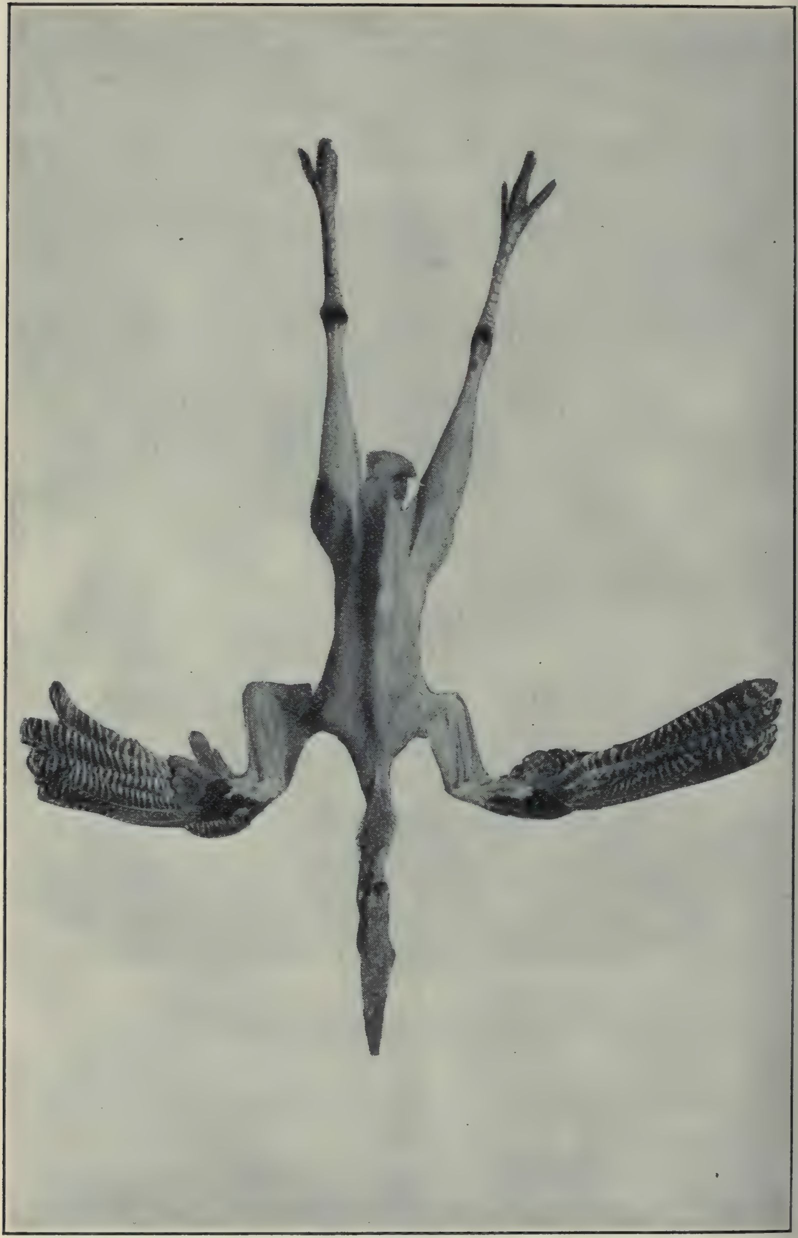


FIGURE 5.—An emaciated carcass. Turkeys as poorly fleshed as this are not placed in any United States grade.

GENERAL RULES THAT APPLY TO PACKING

PACKAGES

The containers in which turkeys are packed must be clean, odor- ss, and of sufficient strength to carry the birds in good condition. soiled package may mean a soiled turkey later, and a broken ackage may permit the turkeys in it to be damaged. Objectionable ackage odors may be caused by dirty or moldy packages or by lors that are characteristic of pine or some other boxing material.

Boxes used should be made of the best quality of lumber, should be ree from knots, evenly and accurately cut, and preferably surfaced 1 both sides. Cement-coated sixpenny nails should be used in the des and bottoms if the boxes are to be nailed, and fivepenny wire ails, not coated, should be used when nailing the cover. Boxes of naller size are preferred to the larger sizes; if the larger ones are sed, they should be wired around both ends.

During recent years a new type of wire-bound box has gradually een replacing the nailed box, as it is lighter in weight. Either type f box may be used in connection with the United States standards the box is sufficiently strong to carry well.

The use of barrels as containers in which to pack turkeys is gen- ally discouraged, but at the present time they may be used in onnection with these standards.

BOX LINING

The package should always be lined with a parchment or waxed- aper liner of good quality. These liners, if of good quality, not ly keep the turkeys clean but protect them from skin drying and rom abrasions caused by rubbing against the sides of the box.

Before stamping the United States grade name on any box, the rader must see that the box has a suitable liner.

STAMPING

An official stamp showing the United States grade of the turkeys ontained in the package may be used only by an authorized grader by some one under his direct supervision. The grade designation ould be plainly legible, should be at least three-quarters of an inch 1 height, and the stamp should be approved by the Bureau of gricultural Economics before it is used. The grade must be amped on the end of the box, the stamp being neatly applied in conspicuous place. In addition to the grade, the class must always e marked on the package immediately following the grade, in letters s conspicuous as those used in marking the grade. The number f turkeys in the container and the net weight of the turkeys must lso be shown.

UNIFORMITY

Turkeys must be packed with a high degree of uniformity in size d color. Good appearance in a box of turkeys is almost completely cking if there is lack of uniformity in the pack. The range of eights of the individual birds in a container, except in the case of d toms, cannot vary more than 2 pounds if proper sizing is maintained and if a good solid pack is to be obtained. No matter how good a job the packer may do, the turkeys will not present an even appearance if uniformity in size is not maintained. Light-colored, milk-fed turkeys should be packed separately from the yellow-colored o grain-fed birds. Most markets prefer the light-colored birds, a fe prefer yellow-skinned birds, but no market prefers mixed colors i a package.

DEFECTS AND DEFORMITIES TO BE CONSIDERED IN GRADING

Defects are usually caused by poor workmanship in dressing whereas deformities are usually due to inheritance or to injury or t conditions existing during the growth of the turkey. Any perso who grades turkeys should have clearly in mind what is meant b certain terms that are used in describing the standards for the different classes and grades.

BRUISES

Large numbers of bruised turkeys are found on the market eac year, bringing great losses to producers and packers. Imprope handling of the live turkeys on the farms and at the packing plant is the chief cause. With proper care this loss could be avoided. A bruise on the breast is considered a much greater defect than a bruis on any other part of the carcass. The extent to which the grade o the carcass is lowered depends on the extent and location of th bruise. (Fig. 6.)

TORN SKIN

How serious the effect of a torn skin is depends on the location When on the back or wings, the tear is not considered so serious a if it is on the breast, and larger tears are allowed on those parts o the carcass. Most tears are due to poor sticking, which makes th feathers difficult to pull. Pulling against the slant of the feather also causes many tears, especially on the younger birds.

The skin of the bird is nature's protection for the meat underneath If it is injured or torn, spoilage begins rapidly where the meat i exposed to the air. For that reason no open tears in the skin ar permitted in U. S. Special and U. S. Prime grades. (Fig. 7.)

SKIN ABRASIONS

Abrasions are marks on the skin that cause it to be rough and discolored. The damage is usually to the outer layer of skin and doe not penetrate to the flesh. Abrasions are usually caused when th turkey is being dressed by rubbing the skin to get the feathers ou instead of picking them out. They may also be caused by roug handling after the birds are killed. Abrasions are most common o the leg, near the knee, and on the wings. When the outer layer o skin, or cuticle, is removed by rubbing or "slapping" in dressing, th inner layer turns dark as it dries out from exposure to the air Abrasions are one of the most objectionable faults brought abou by unskillful dressing.

POOR BLEEDING

Good bleeding is highly important. A bird that has been poorl bled soon develops a characteristic "strong" taste and an offensiv odor. Its keeping quality is not so good as it would be if the bird had been well bled. When a turkey has not been completely bled, small red pin spots show along the tip of the wings and over the hips. If the bleeding was not complete these blood marks show wherever the larger feathers have been pulled. The marks are most

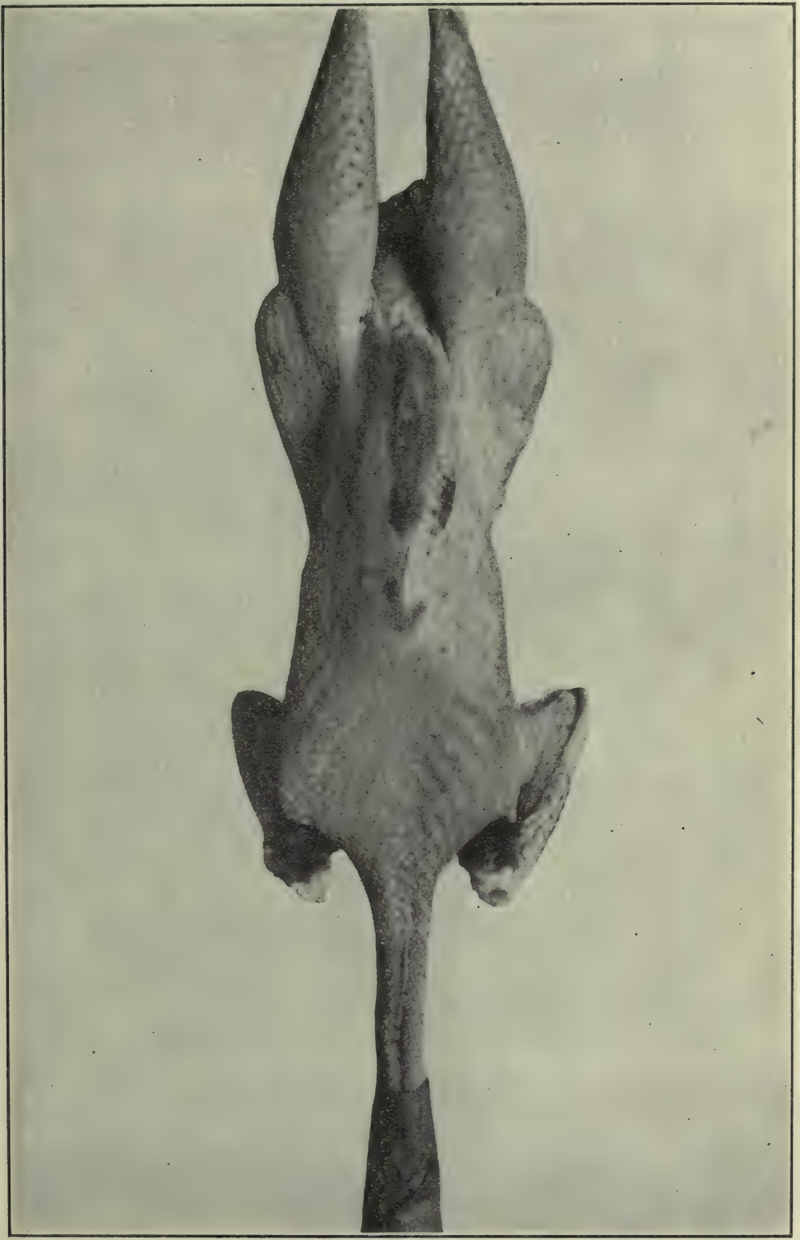


Figure 6.—Turkey with bruised breast. This turkey was placed in U. S. Commercial grade, or U. S. Grade C. Except for the bruise, it would have graded U. S. Prime, or U. S. Grade A.

noticeable on the tail, along the thigh, and on the streak of fat that extends over either side of the breast. If the bleeding was done very poorly the neck is blue and discolored from blood clots that form underneath the skin.

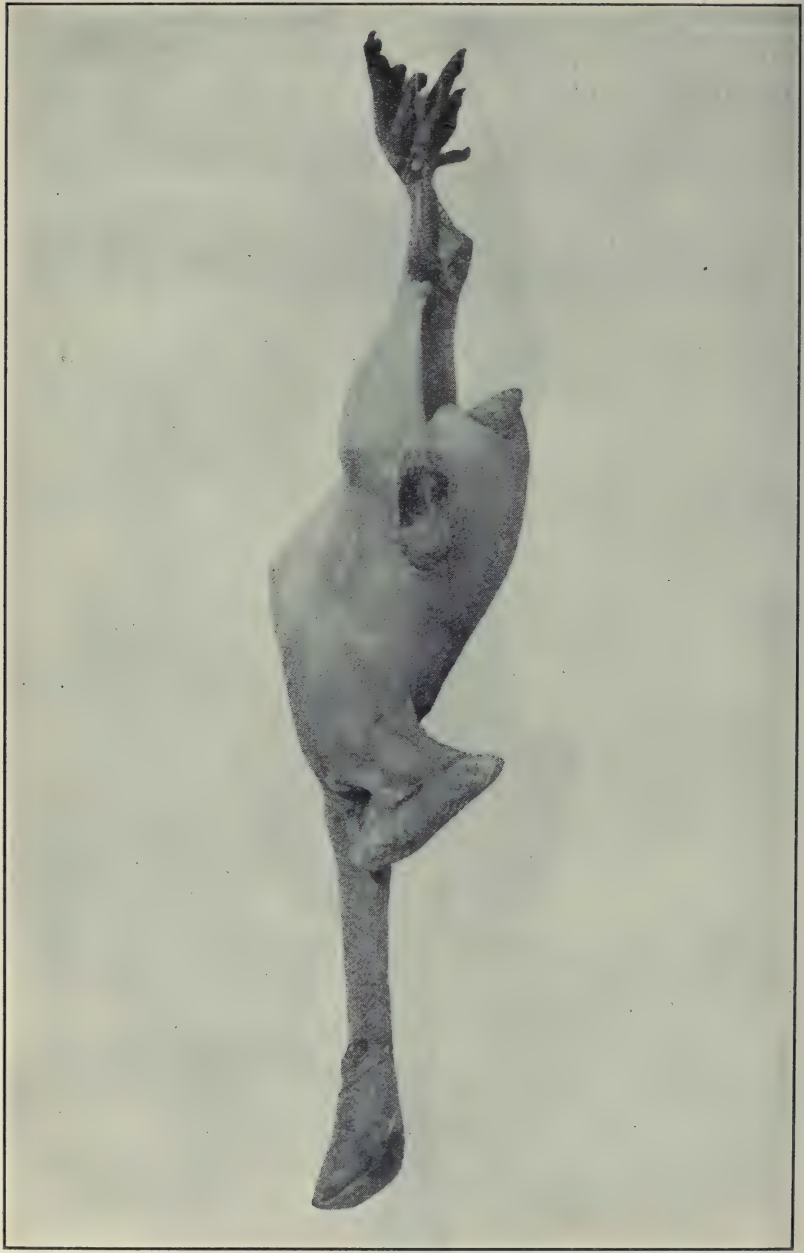


FIGURE 7.—This U. S. Prime, or U. S. Grade A, turkey is reduced to U. S. Commercial, or U. S. Grade C, on account of torn skin. Had the tear been properly sewed up or had it occurred on the back or wing, the turkey would have graded U. S. Choice, or U. S. Grade B.

DISCOLORATION

Skin discoloration or reddening is often caused by the carcasses touching each other on the cooling racks. It may also result from a sweat after they are packed if they are not kept sufficiently cool. If the skin is not thoroughly dry when the turkeys are packed, discoloration is likely to occur wherever one bird rests against or touches another. Usually a slightly bloody liquid will form under the skin at the juncture of contact causing it to appear red. Discoloration of the skin over the crop often occurs if the turkey swallows blood while bleeding after it has been stuck in the mouth.

CROOKED BREASTS

A very crooked breast is a common cause for disqualifying birds for the higher grades. Crooked breastbones, according to most authorities, are sometimes due to improper feeding—usually to a lack of minerals in the feed. Some inherited tendencies also cause weak bony structures in offspring from defective breeding stock. Crooked breasts are not allowed in the U. S. Special or U. S. Prime grades. The extent or degree to which the breast is crooked is one of the principal factors in determining the grade. If the breastbone is slightly curved but not crooked and if the curvature does not interfere with the slicing of the meat, the bird may be graded U. S. Prime. (Fig. 8.)

DENTED BREASTBONES

A dent is a notch in the breastbone. It is caused by the turkey resting its breast on the roost. It is not considered so serious a defect as a crooked breast because it does not interfere with the slicing of the breast meat as much as does a crooked breast. (Fig. 9.)

PEAKED BREASTS

A peaked breastbone results in a deformed breast and should be considered equivalent to a slightly crooked breast. It does not affect the eating qualities of the meat, but lowers the commercial value of the bird considerably from the standpoint of appearance and puts the bird in a grade below U. S. Prime. (Fig. 10.)

CROOKED BACKS

Any deformities in the bones of the back which throw the body out of line is known as a crooked back. Usually such a deformity is not noticeable when one is looking at the breast of the turkey, and it is far less serious than a hunchback as it does not throw the meat of the breast out of line. A turkey with a crooked back cannot be placed in a grade above U. S. Choice.

HUNCHBACKS

A hunchback is considered as a major deformity in a turkey. If the bird is fairly well fleshed it may be placed in the lowest grade, but if not, the bird will be below any grade. Such turkeys, even when well-fleshed, bring low prices. (Fig. 11.)

CROOKED FEET AND TOES

Crooked, misshapen feet and toes are common deformities among turkeys. If they are only slightly misshapen no attention need be paid to them in grading, but if they are definitely deformed the turkey may not be put in the U. S. Special grade. If the feet or toes

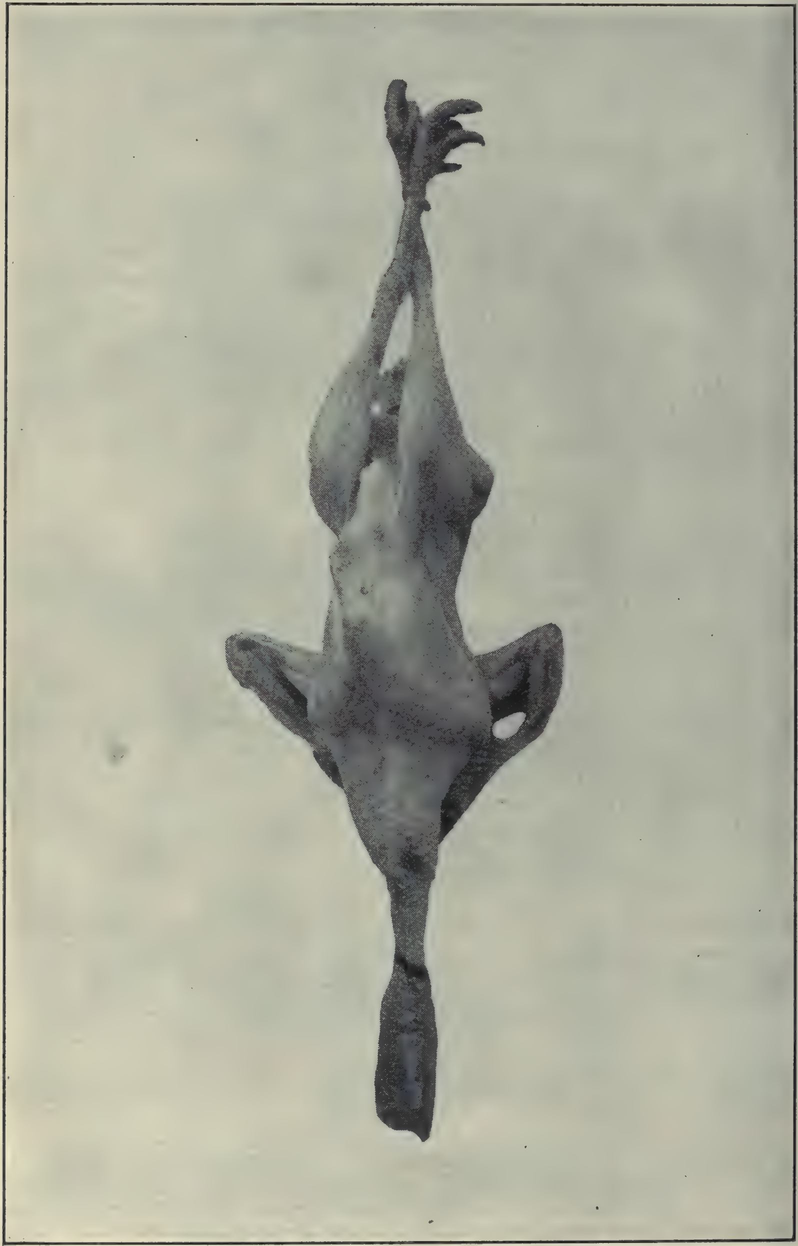


FIGURE 8.—Turkey with a crooked breastbone. A deformity as marked as this places the carcass in the lowest grade.

are badly misshapen the turkey is placed in the U. S. Prime grade only if it is otherwise of U. S. Special quality.

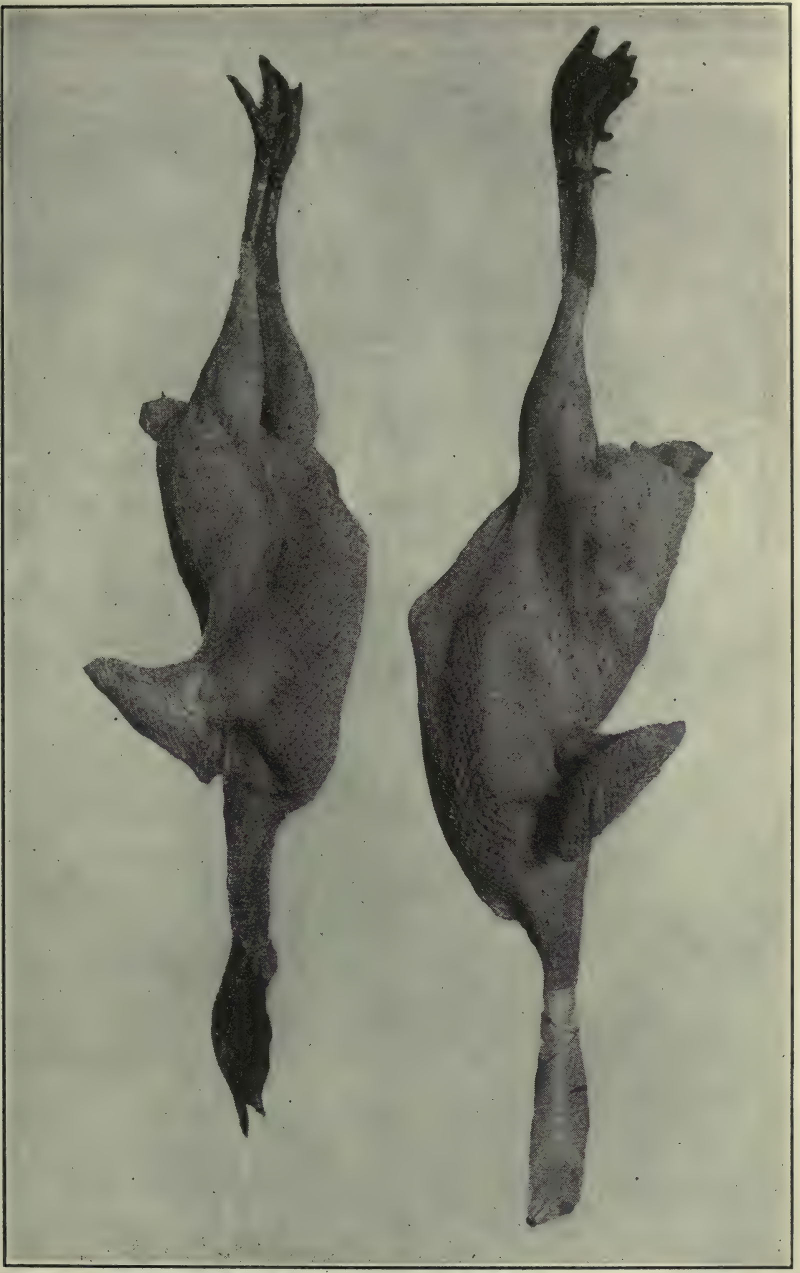


FIGURE 9.—Turkeys with dented breastbones. The dent in the breast of the turkey on the right measured one-eighth of an inch in depth; the one on the left, one-fourth of an inch in depth.

STAGGINESS

Producers often make the mistake of holding their young toms until the flesh is no longer fine-grained and tender. The bird must then be placed in a lower grade. In grading chickens a separate class is provided for such birds, and they are called stags, but such

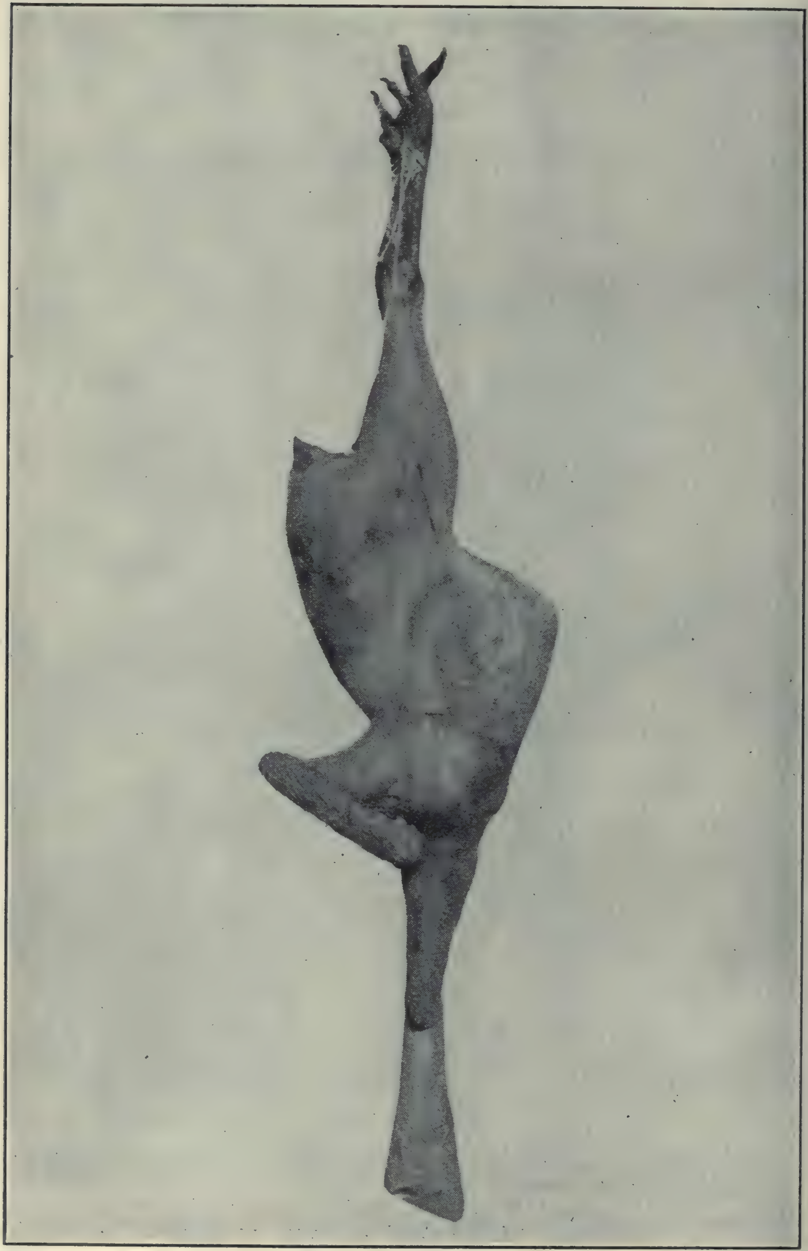


FIGURE 10.—Turkey with a peaked breastbone. If full-fleshed and properly dressed, this turkey would grade U. S. Choice, or U. S. Grade B; if not full-fleshed, it would grade U. S. Commercial, or U. S. Grade C.

is not the case with turkeys. Instead, they are placed in a lower grade. (Fig. 12.)

SCALY LEG

Scaly leg in turkeys is due to infestation of mites on the legs. This trouble should be cured by the producer before his turkeys are ready for market. Dipping the legs of the affected bird once in

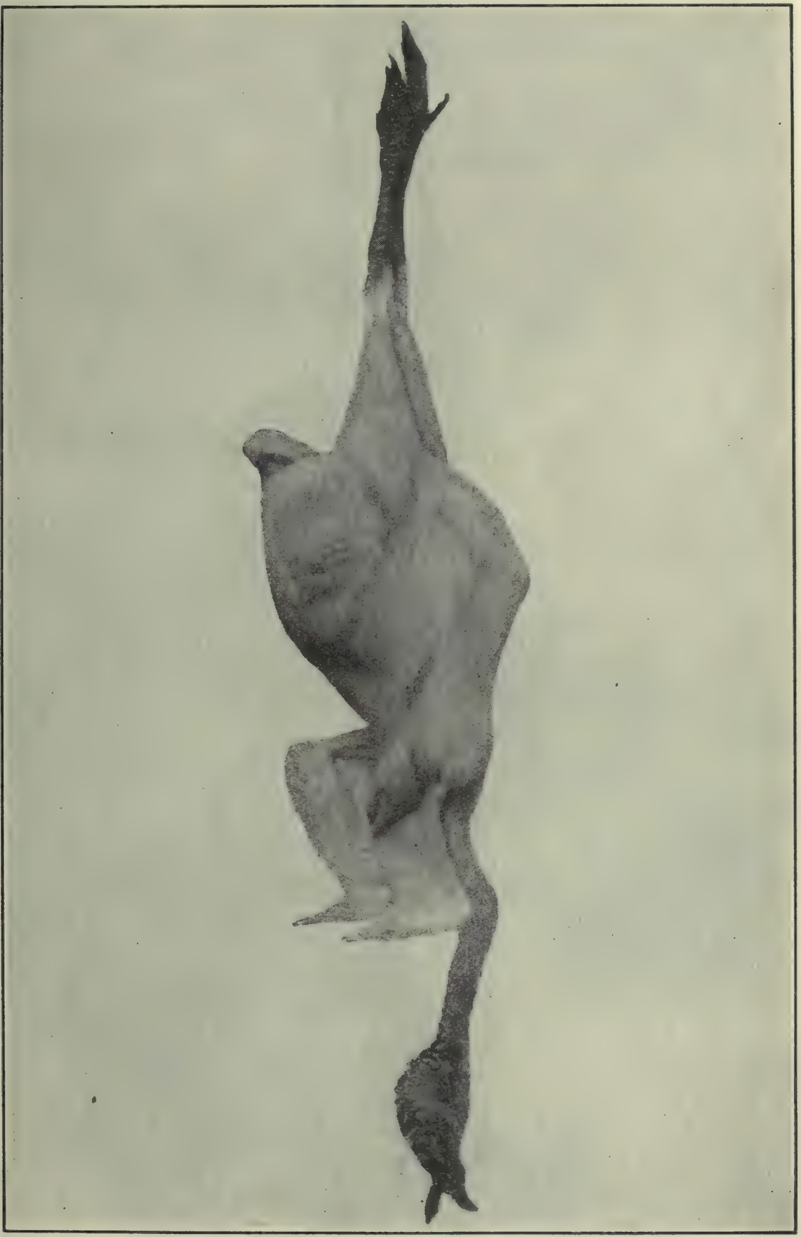


FIGURE 11.—A well-fleshed turkey with a hunched back. As this turkey is well-fleshed it will be placed in U. S. Commercial grade, or U. S. Grade C.

crude petroleum or in a mixture of 1 part kerosene and 2 parts raw linseed oil will usually cure the trouble. If the condition has reached an advanced stage at the time the bird is graded, the carcass should be reduced at least one grade. (Fig. 13.)

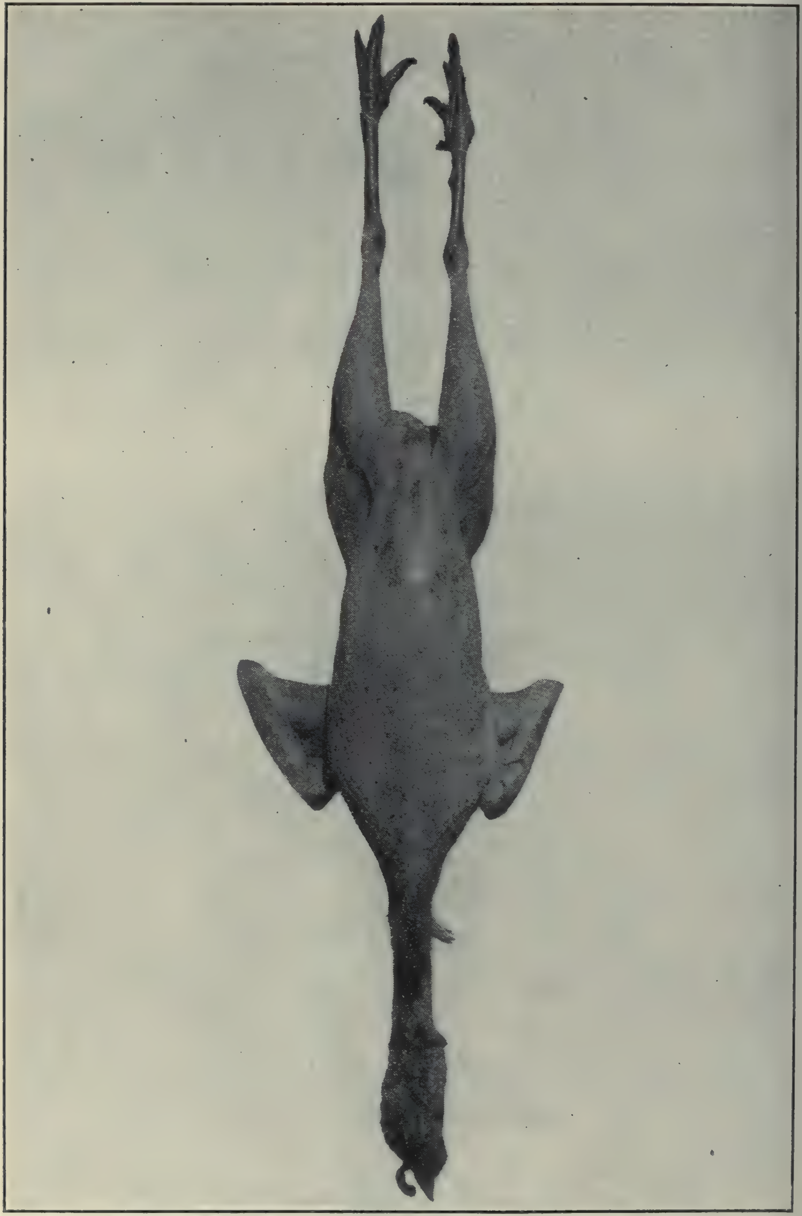
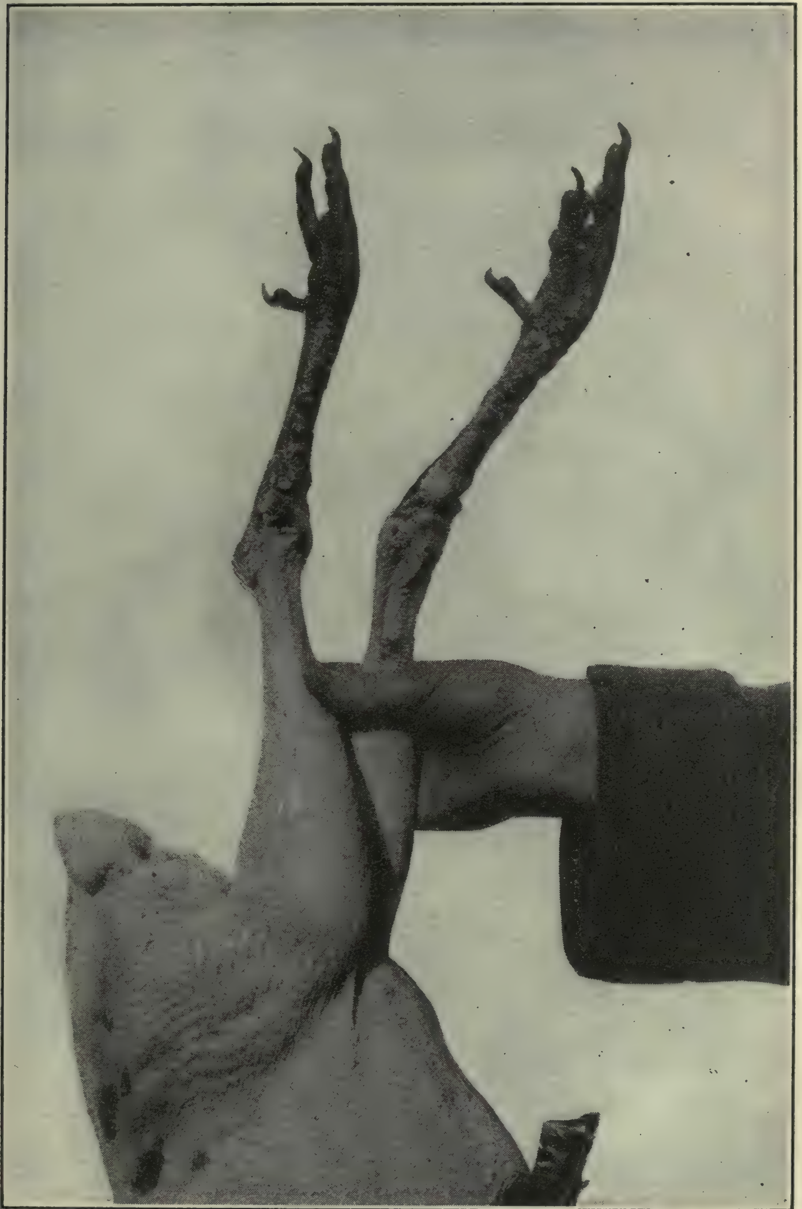


FIGURE 12.—A staggy young tom. As the spurs and head are well developed and the breast has become puffed and flabby, this turkey belongs in the grade of U. S. Choice young tom.

INTERNAL FEATHER GROWTH

Internal feather growth is more prevalent in old hen turkeys than n any other class. Affected turkeys will have a rough, scaly skin. The ends of the feathers will protrude slightly through the cuticle, he remaining part of the feathers, sometimes 3 or 4 inches, being nderneath the skin. The producer can do nothing to remedy this



IGURE 13.—A turkey affected with scaly leg. The skin above the knee is dark and wrinkled. The turkey is barred from the U. S. Special, or U. S. Grade AA.

condition, and it is almost impossible to detect it until after the turkey has been killed and picked. In severe cases the affected turkey should be placed in the lowest grade. (Fig. 14.)

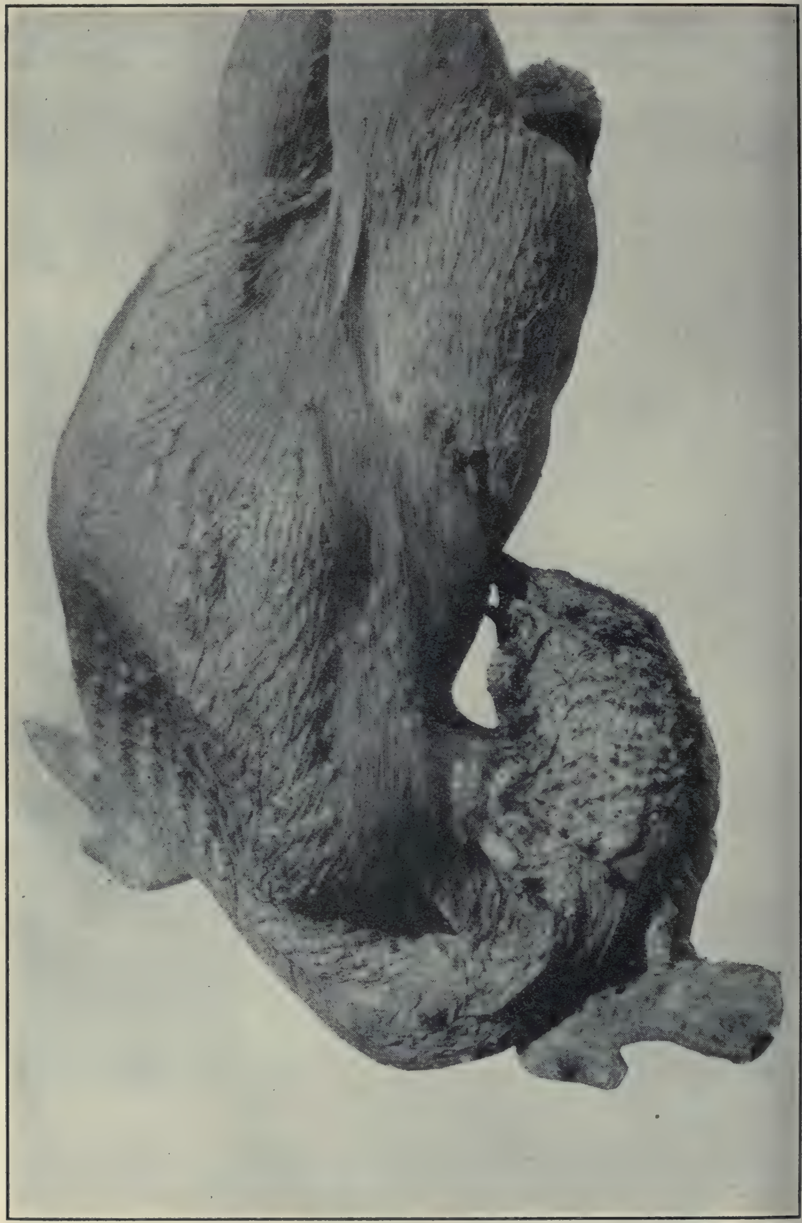


Figure 14.—Turkey showing evidence of internal feather growth. This turkey has been reduced in grade from a U. S. Prime, or U. S. Grade A Old Hen to U. S. Commercial, or U. S. Grade C Old Hen.

SWOLLEN JOINTS

Swollen joints constitute a minor deformity. Turkeys so affected are barred from the U. S. Special grade. If the joints are badly swollen the turkey should be placed below the U. S. Prime grade. (Fig. 15.)

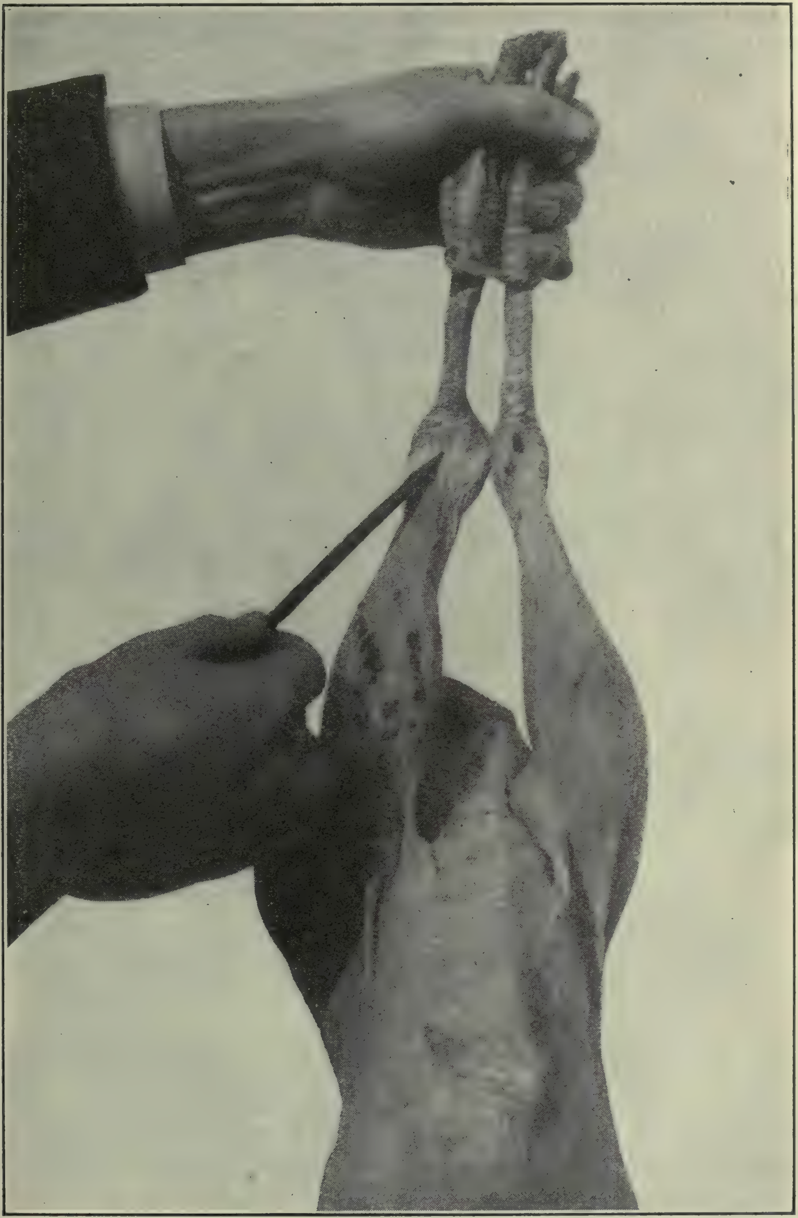


FIGURE 15.—Turkey with swollen joints. When the leg is so affected the turkey must be reduced one grade.

PIGMENTED SKIN

Pigmented skin means that the skin has turned a bluish-green color because of a feather pigment growing under the skin. It is caused by injury to feather follicles and is prevalent in flocks in which tail picking has occurred. It is also commonly found on the backs of breeder hens that have been injured by the treading of the toms. No skin pigmentation is permitted in the U. S. Special grade; it is permitted only on the tail of a bird that is U. S. Prime; and no further than the hips on a bird that is U. S. Choice. (Fig. 16.)

WEIGHT SPECIFICATIONS

Under the United States standards the weight of the individual bird is not a factor in determining its grade. If a turkey has the required fleshing characteristics and other qualities, it may be placed in the top grade regardless of its weight.

Ordinarily hen turkeys that weigh less than 9 pounds or tom turkeys that weigh less than 12 pounds will not be sufficiently fleshed or finished to meet the requirements of the U. S. Special and U. S. Prime grades, but this is not always the case. It is possible for turkeys that have been properly raised and dressed and weigh only 6, 7, or 8 pounds to be of U. S. Prime grade; when they meet all other qualifications they are placed in that grade regardless of weight.

It is always desirable to pack the smaller turkeys separate from the larger and mark them accordingly. The weight of individual birds in one box must not vary more than 2 pounds unless they are old toms, and it is preferable to limit the weight range to 1 pound. If the 2-pound variation is used, the weight classifications shown in table 1 are recommended.

TABLE 1.—*Weight classifications for dressed turkeys*

Old or young hens (pounds)	Young toms (pounds)	Old toms (pounds)
Under 8	Under 12	Under 18.
8 to 10	12 to 14	18 to 24.
10 to 12	14 to 16	24 to 30.
12 to 14	16 to 18	30 and over.
14 and over	18 to 20	
	20 to 22	
	22 and over	

An exception to this weight classification is made in the U. S. Commercial grade. Birds of a 3-pound weight variation may be packed together in that grade.

GRADE LABEL AND STAMP

When individual turkeys are graded according to United States standards, each turkey may be individually labeled with its United States grade or the box or barrel in which the turkeys are packed may be stamped with the United States grade (p. 32). The grade label or tag that is used on the bird also gives the class and age of the turkey. (Fig. 17.)

The label is fastened to the carcass by means of an approved metal seal and cannot be removed without destroying the seal. Different-

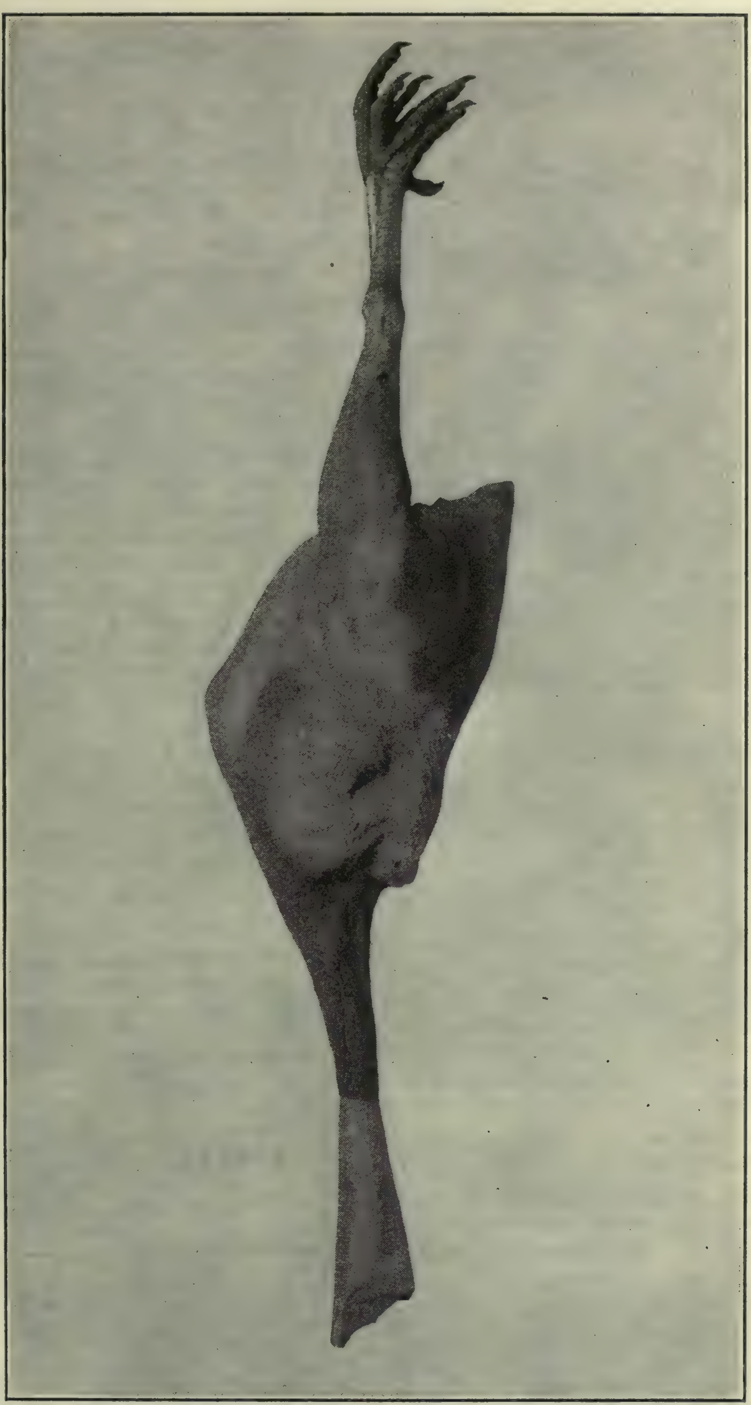


FIGURE 16.—Turkey with pigmented skin. The discoloration extends beyond the tail and half way to the hips. This turkey would be graded U. S. Choice, or U. S. Grade B.

colored labels are now being used for the different grades. Turkeys of the U. S. Commercial grade are not individually labeled. Whether or not the packer or shipper of turkeys wishes to have the individual turkeys labeled, he may have the outside of the package stamped with the Government grade. This stamp gives the grade of the turkeys in the package, the grader's number, and the date of grading. (Fig. 18.)

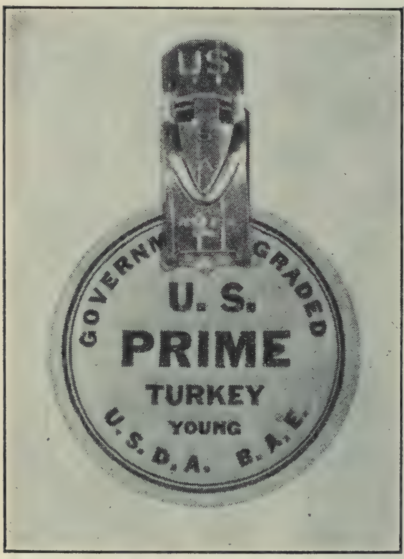


Figure 17.—Seal and tag used to label the grade on an individual turkey. They are usually attached to the skin of the neck or the web of the wing.

LICENSE CARD

When an applicant has been examined and found to possess the proper qualifications to grade turkeys in accordance with the United States standards, he is eligible to receive a grader's license card, which authorizes him to do this work. A grader's card is not issued, however, unless the applicant has grading work to perform for an individual or firm who has applied for the grading service to the agency with which the Bureau of Agricultural Economics is cooperating in carrying on the grading work. The license card empowers the grader to certify to the class, grade, and condition of dressed turkeys. The signature of the immediate superior officer or of a representative of the Bureau of Agricultural Economics is affixed to the card. The date on which the card becomes invalid is plainly marked on the card. These cards are issued only from season to season and must be renewed each year.

Persons who have a financial interest in the turkeys to be graded—plant or pool managers or their close relatives, for instance—are not eligible to be licensed. Producers are not licensed to grade their own turkeys.

As soon as the expiring date has been reached or as soon as the grader has finished his work for the season, the license card must be returned to his immediate superior officer, who must return it to the Bureau of Agricultural Economics, Washington, D. C.

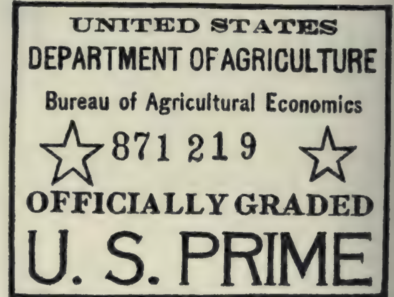
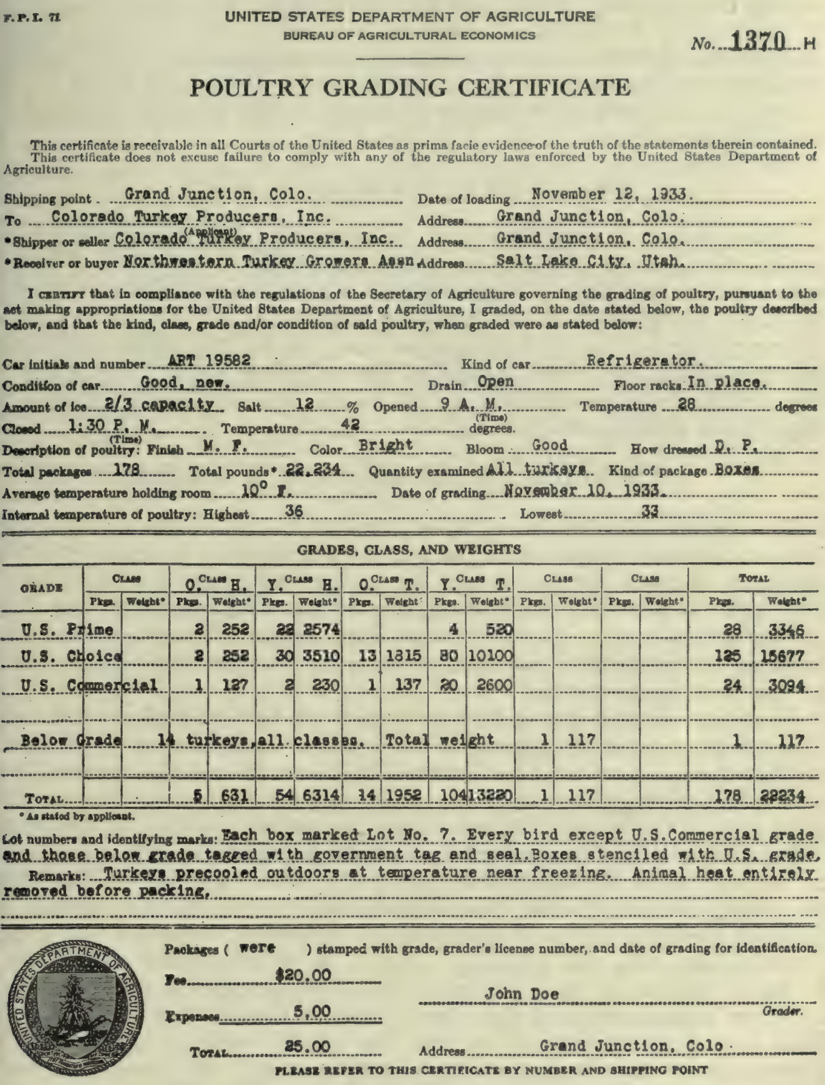


Figure 18.—Impression of a Government stamp used in marking packages. These stamps are issued only to licensed turkey graders.

A licensed grader is not permitted to draw his salary from the plant or pool for whom the grading work is done. The salary is paid by the applicant for the service to the State cooperating agency, which in turn remits the salary to the grader.

GRADING CERTIFICATE

A grading certificate is issued for each lot or car of turkeys graded. (Fig. 19.) The original and one copy of the certificate are delivered o the shipper or to the receiver of the turkeys, whichever applied or the grading, one copy is mailed to the Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C., and one copy is sent to the supervisor. The grader may retain copy if he wishes. The certificate is typewritten whenever practiable. It contains full information regarding the number of boxes f each class and grade in the lot, and net weight of each class and



F.P.I. 71

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF AGRICULTURAL ECONOMICS

No. 1370 H

POULTRY GRADING CERTIFICATE

This certificate is receivable in all Courts of the United States as prima facie evidence of the truth of the statements therein contained. This certificate does not excuse failure to comply with any of the regulatory laws enforced by the United States Department of Agriculture.

Shipping point Grand Junction, Colo. Date of loading November 12, 1933.
To Colorado Turkey Producers, Inc. Address Grand Junction, Colo.
*Shipper or seller (Applicant) Colorado Turkey Producers, Inc. Address Grand Junction, Colo.
*Receiver or buyer Northwestern Turkey Growers Assn Address Salt Lake City, Utah.

I CERTIFY that in compliance with the regulations of the Secretary of Agriculture governing the grading of poultry, pursuant to the act making appropriations for the United States Department of Agriculture, I graded, on the date stated below, the poultry described below, and that the kind, class, grade and/or condition of said poultry, when graded were as stated below:

Car initials and number ART 19582 Kind of car Refrigerator.
Condition of car Good, new. Drain Open Floor racks In place.
Amount of ice 2/3 capacity Salt 12 % Opened 9 A. M. (Time) Temperature 28 degrees
Closed 1:30 P. M. (Time) Temperature 42 degrees.
Description of poultry: Finish M. F. Color Bright Bloom Good How dressed D. P.
Total packages 178 Total pounds* 22,234 Quantity examined All turkeys Kind of package Boxes
Average temperature holding room 10° F. Date of grading November 10, 1933.
Internal temperature of poultry: Highest 36 Lowest 33

GRADES, CLASS, AND WEIGHTS

Grade	Class		O. Class H.		Y. Class H.		O. Class T.		Y. Class T.		Class		Class		Total	
	Pkgs.	Weight*	Pkgs.	Weight*	Pkgs.	Weight*	Pkgs.	Weight*	Pkgs.	Weight*	Pkgs.	Weight*	Pkgs.	Weight*	Pkgs.	Weight*
U.S. Prime			2	252	22	2574			4	520					28	3346
U.S. Choice			2	252	30	3510	13	1315	80	10100					125	15677
U.S. Commercial			1	127	2	230	1	137	20	2600					24	3094
Below Grade	14 turkeys, all classes. Total weight										1	117			1	117
Total			5	631	54	6314	14	1952	104	13220	1	117			178	22234

* As stated by applicant.

Lot numbers and identifying marks: Each box marked Lot No. 7. Every bird except U.S.Commercial grade and those below grade tagged with government tag and seal. Boxes stenciled with U.S. grade.

Remarks: Turkeys precooled outdoors at temperature near freezing. Animal heat entirely removed before packing.

Packages (were) stamped with grade, grader's license number, and date of grading for identification.

Fee $20.00
Expenses 5.00
Total 25.00

John Doe
Grader.

Address Grand Junction, Colo.

PLEASE REFER TO THIS CERTIFICATE BY NUMBER AND SHIPPING POINT

FIGURE 19.—A grading certificate made out in full.

grade, with other valuable information. It also states the condition of the carcasses. Each certificate is signed by the grader, who certifies to the truth of the statements contained therein.

The certificates are serially numbered, and a record of each is kept. When a certificate is lost or destroyed, the grader must immediately notify his superior officer. If the certificate should be torn, soiled, or incorrectly made out, it must be marked "void" and sent to the supervising grader. At the close of the grading season all unused grading certificates must be mailed immediately to the State supervisor, who in turn promptly mails them to the Bureau of Agricultural Economics.

REGRADING AT TERMINAL MARKETS

The terminal-market buyer or receiver of a lot or car of turkeys which was graded at shipping point according to the United States standards, may obtain a regrading of the lot at any terminal market at which the United States grading service on turkeys is available. If regrading is done at the terminal market, the regrading certificate supersedes the certificate issued at the shipping point. Therefore if the grading at the shipping point is not done correctly, it will be recognized and the shipper will be in trouble.

OUTSTANDING CONSIDERATIONS IN GRADING

The grader should always bear in mind the three factors of major importance that determines the grade of a dressed turkey: (1) The quantity of flesh on the carcass in comparison with the quantity of the inedible portion, (2) the quality of the flesh, and (3) the sales appeal of the bird as typified by its appearance. A turkey must rate high in all three of these factors in order to meet the requirements of the two higher grades.

It is not enough for a turkey merely to be full-fleshed and soft- and tender-meated; it must also show good workmanship in dressing so that the sales value is not lowered by blemishes on the carcass, torn or abrased skin, pinfeathers, or other defects that spoil the appearance even though they do not lower the eating quality of the meat.

It is impossible for graders to render a satisfactory grading service according to the United States standards unless they have a thorough knowledge of the United States standards for classes and grades of dressed turkeys. This is obtained by a careful study of the grade descriptions and the grading chart. A good grader soon comes to know almost at once the grade in which a carcass will be placed after an examination of the characteristics that determine its grade. This may appear difficult at first, but if the work is undertaken in a systematic way, the knowledge comes readily. To insure uniformity in grading, some graders select, early in the day, a number of turkeys that are fully typical of each grade and hang them on a rack where they can be conveniently referred to. Then if there is doubt in regard to any bird graded later, a comparison with those on the rack will indicate the correct grade. Graders are expected to attend one of the turkey-grading schools held in various parts of the country each year, to keep in touch with newest developments and in line with other graders.

There are always a number of turkeys near the median line between wo grades. In grading at a shipping point, such “line birds” are isually placed in the lower grade because natural changes, occurring n transit, often would necessitate placing them in a lower grade y the time they reach the market. When the grading is done at the erminal market, the line birds may more safely be placed in the igher grade.

When producers bring dressed turkeys to concentration plants, hey may want information about the methods of grading or reasons or placing a certain bird in a certain grade. Graders who are super- ised by the Government are advised to make careful and patient xplanation to all inquirers who have an interest in the birds being andled. Strict grading eventually benefits the producers by creat- ng a demand for turkeys so graded. On many markets a preference s shown for the United States graded and labeled turkeys. When roducers understand this thoroughly they are ready to endorse the ork.

Graders keep in close touch with the State supervisor who is their nmediate supervising officer. In case of argument or uncertainty his supervisor is consulted. The supervisor is held responsible for he grading work in his State and, in turn, holds each grader esponsible for the work performed by him. Through these and imilar measures a grading service has been built up that is gradually enefiting producers, dealers, and consumers.

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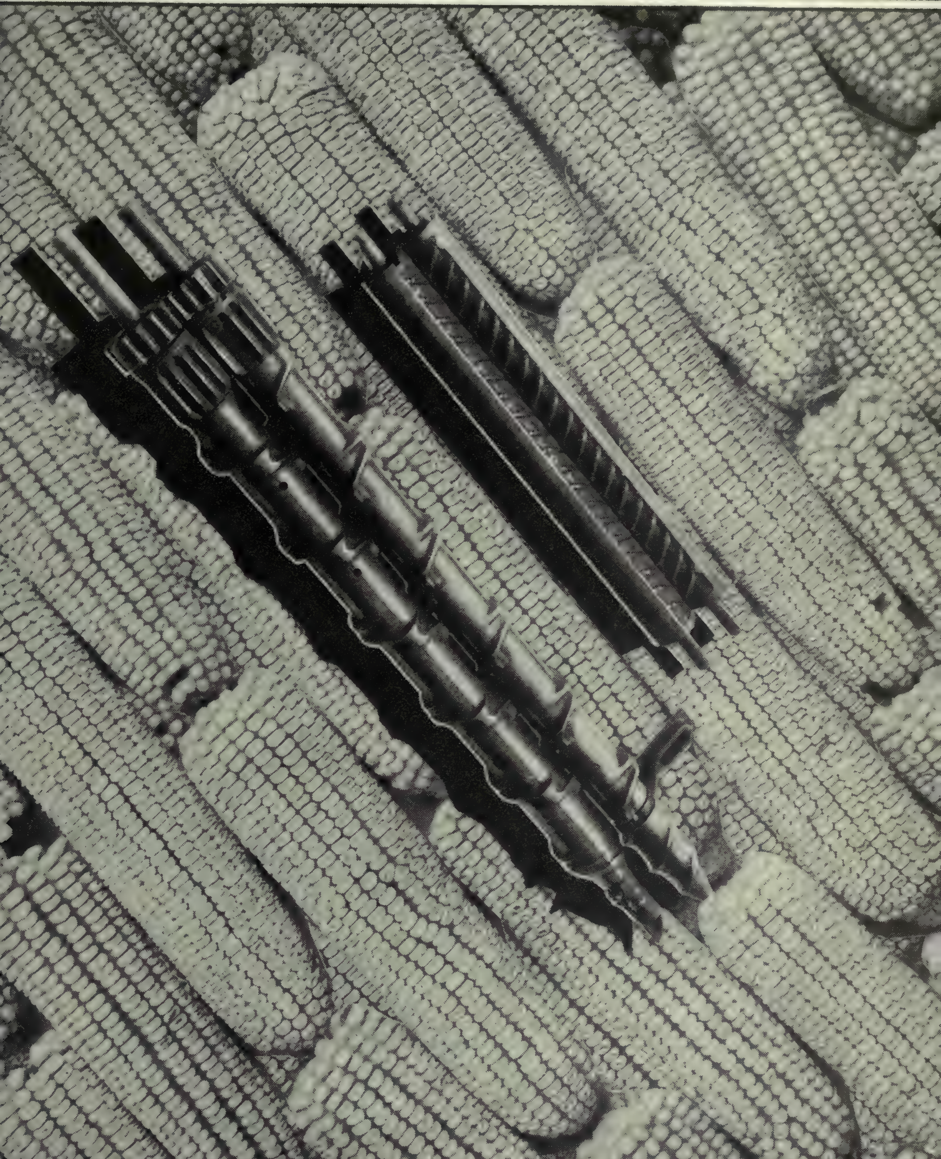
ECHANIZING THE
CORN HARVEST



FARMERS' BULLETIN No. 1816

S. DEPARTMENT OF AGRICULTURE

CORN-PICKER PERFORMANCE

An ordinary corn crop harvested as grain in the United States is about 2 billion bushels or 70 million tons of ear corn. If harvested by hand, the total harvesting labor is estimated as 250 million man-hours.

Single-row horse-drawn machine corn pickers were sold in limited numbers as early as 1904. Two-row tractor pickers first came on the market in 1928. The number of these machines in use on large corn farms has increased rapidly, but probably more than 90 percent of the United States' crop is still harvested by hand.

Time studies of corn harvesting by machine show that the total labor of harvesting with the best machinery now available is about one-fourth of the labor required for hand husking.

Under unfavorable conditions machine corn pickers leave more corn in the field than do hand pickers.

In the central part of the corn belt field losses with machines increase after the first of November, when the cornstalks deteriorate as a result of weathering. Machine picking should be finished early in November.

Corn-picker performance can be materially improved by growing a corn hybrid which is well adapted to machine harvesting.

Machine harvesting has a special advantage on farms where general-purpose tractors are already in use for tillage operations.

Corn pickers can be and are operated safely by a large proportion of the farmers who use them.

THE COVER DESIGN

The front cover shows the two most characteristic parts of the mechanical corn picker—the snapping rolls (lower), which break the ears from the stalks, and the husking rolls, which tear the husks from the ears. The picture shows the rolls much reduced in size in comparison with the ears of corn.

Washington, D. C. **Issued December 1938**

MECHANIZING THE CORN HARVEST[1]

By Claude K. Shedd, *agricultural engineer, Division of Mechanical Equipment, Bureau of Agricultural Engineering*, and Edgar V. Collins, *research professor of agricultural engineering, Iowa State College*

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INTRODUCTION

HARVESTING THE CORN CROP requires more labor than harvesting all the other grain crops. The weight of corn to be handled is greater, and the work is done largely by hand, whereas small grain is harvested by machine.

According to the Statistics of Agriculture, 1937, the 1935 crop of corn harvested as grain in the United States was 2,015,007,000 bushels; the total production of all other grains was 2,281,887,000 bushels. In round numbers the ordinary corn crop harvested as grain is about 2 billion bushels, which as ear corn at 70 pounds per bushel weighs 70 million tons. The total of all other grain crops is about 2¼ billion bushels, or 50 million tons of threshed grain.

The purpose of this bulletin is to aid the farmer in deciding what corn-harvesting methods and equipment are best in his circumstances.

HARVESTING METHODS

There are two methods of harvesting corn as grain. One method consists of cutting and shocking the corn before frost and husking out the ears after the fodder has cured. This method is followed where the acreage of corn per farm is small and in portions of the Corn Belt where winter wheat follows corn. Because of the large amount of labor involved it is impractical where a large acreage of corn is grown for grain. The other method is to allow the corn to stand until the ears are dry enough for storing when the ears are husked from the standing stalks. This is the usual procedure in regions where corn is grown in large quantities primarily for grain and where a spring-seeded crop follows the corn.

Recently in parts of the Corn Belt there has been considerable interest in combining, or field-shelling, corn. However, as combining has been employed only to a limited extent, it is not discussed in this bulletin.

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[1] Projects 394 and 476 of the Iowa Agricultural Experiment Station.

LABOR OF HAND HUSKING

The labor used for husking corn from standing stalks by hand varies widely with the yield of corn and the strength and skill of the huskers. The custom of paying wages by the bushel has no doubt had an influence in developing skill. A spirit of athletic competition has also played its part in the development of speed. The best performers in recent husking contests have husked approximately 40 bushels in the standard 80-minute period, that is, 30 bushels per hour.

In Iowa a labor record was obtained on a typical farm where husking was done by hand. With a yield of 70 bushels per acre the total harvesting labor per acre was 9 man-hours, 7.5 hours of which was spent in the field and the other 1.5 hours in taking care of horses and unloading the corn from wagons into cribs by hand scooping This was at the rate of 7.8 bushels per hour of total labor.

In central Illinois labor records were obtained of the hand husking of 392 fields comprising a total of 11,835 acres during 1920 to 1928 and were reported on in Illinois Station Bulletin 373, Harvesting the Corn Crop in Illinois. The average labor requirement per acre was found to vary with yield as follows: 30 bushels, 4.00 man-hours; 40 bushels 4.60 man-hours; 50 bushels, 5.38 man-hours; 60 bushels, 5.72 man-hours; and 70 bushels, 6.23 man-hours. The average rate of work in bushels per man-hour ranged from 7.92 with low yields to 10.82 with high yields.

In central Indiana according to Indiana Station Bulletin 362, Mechanical Corn Pickers in Indiana, the average labor requirement for hand husking was 5.35 man-hours per acre with yields of 40 to 50 bushels per acre.

The average yield of corn in the United States is between 25 and 30 bushels per acre. If 8 bushels per man-hour is assumed to be the rate of harvesting by hand, the labor involved in hand harvesting a 2-billion-bushel crop is 250 million man-hours.

DEVELOPMENT OF MECHANICAL EQUIPMENT FOR CORN HARVESTING

Mechanization of harvesting corn by husking the ears from standing stalks in the field started at a much later date than the mechanization of small-grain harvesting. A few machine corn pickers were sold to farmers as early as 1904. The early machines had essentially the same mechanical elements as are now used for snapping and husking the ears, but they were not entirely successful as they were single-row, ground-driven and horse-drawn and were not as well built as later machines. Often little if any more corn was harvested per man than could be husked by hand.

From 1928 to 1933 several large manufacturers began to produce two-row corn pickers, either tractor-drawn or mounted on a general-purpose tractor. The picker mechanisms of these machines were driven by power take-off from the tractor, which also towed a wagon to receive the corn. These arrangements made them one-man outfits. In comparison with the earlier pickers, the machines were improved to accomplish better pick-up of broken or leaning stalks and to reduce clogging. They had structural improvements such as enclosed gears running in oil, steel-roller chain drives, improved bearings with fittings for grease-gun lubrication, and slip clutches to prevent breakage of machine parts in case of clogging. These machines have been successful in field operation and have reduced materially the labor required for harvesting corn in comparison with hand husking. Single-row machines of similar design are also available and may be preferable on the smaller farms. While the number of machine corn pickers in use on farms has increased quite rapidly in recent years, the area harvested by them is probably less than 10 percent of the total acreage of corn harvested for grain.

The job of unloading ear corn from the wagons into cribs on the farm has been mechanized to a greater extent than the husking. Stationary or portable ear-corn elevators are in use on most of the larger farms in the Corn Belt. The elimination of hand scooping is no small saving since many family-size farms produce more than 350 tons of ear corn.

LABOR OF HARVESTING WITH MACHINE PICKERS

Time studies of machine harvesting were started in 1931 and continued through 1937 at Ames, Iowa. Detailed data from 1931, 1932, and 1933 tests were published in Iowa Station Bulletin 365, Labor, Power, and Machinery in Corn Production. The equipment used at that time traveled on steel wheels; that used in 1936 and 1937 was mounted on rubber-tired wheels. Prior to 1937 the corn was stored in small cribs. A portable elevator was used to unload wagons. In 1937 an 8,000-bushel crib with an inside elevator and pit was constructed on the experiment farm near Ames, and this was used when the 1937 time studies were made.

In the tests at Ames whenever conditions were favorable it was found possible to operate pickers at a speed of 3 miles per hour without apparent adverse effect upon machine performance as compared with operation at slower speeds.

If operation were continuous at the 3-mile speed, a two-row machine would harvest 2½ acres per hour, but this is always reduced by time required for turning, for changing wagons, and for other incidental delays.

In the earlier time studies, when the portable elevator was used for unloading wagons, it took two men to haul and unload the corn from a two-row picker in corn yielding 60 to 70 bushels per acre. The two men had some idle time, however. In the 1937 studies, when the inside elevator and dump pit were used, one man was able to haul, weigh, and crib the corn from a two-row picker with yields up to 80 bushels per acre (table 1). The labor required for hauling and cribbing depends upon yield, size of loads, convenience of wagon hitches, length of haul, and speed of travel as well as upon equipment used for unloading. With all of these factors to consider, it it often difficult to plan the crew and equipment so as to avoid having some idle labor.

TABLE 1.—*Time required for corn-picker operations, 1937*

Crew	2 men	1 man.
Length of test	1 hour 27 minutes	1 hour 39½ minutes.
Power for towing wagons	Pick-up truck	Tractor on which picker was mounted.
Distance from field to storage building ... mile	0.4	0.4.
Length of field rows ... rods	40	80.
Average yield per acre ... bushels	79.3	59.8.
Average time to pick 1 load, including stops, turns and coupling ... minutes	14½	
Time to pick 3 loads, including stops, turns, and coupling ... minutes		65½.
Average load ... bushels	34.9	40.3.
Average time to haul, weigh, dump, and elevate 1 load ... minutes	13	
Time to haul, weigh, dump, and elevate 3 loads ... do		34.
Area husked and cribbed per hour ... acres	1.8	1.2.
Corn husked and cribbed per hour ... bushels	143	72.7.
Time required per acre ... man-hours	1.1	0.83.
Corn husked and cribbed per man-hour ... bushels	71.5	72.7.

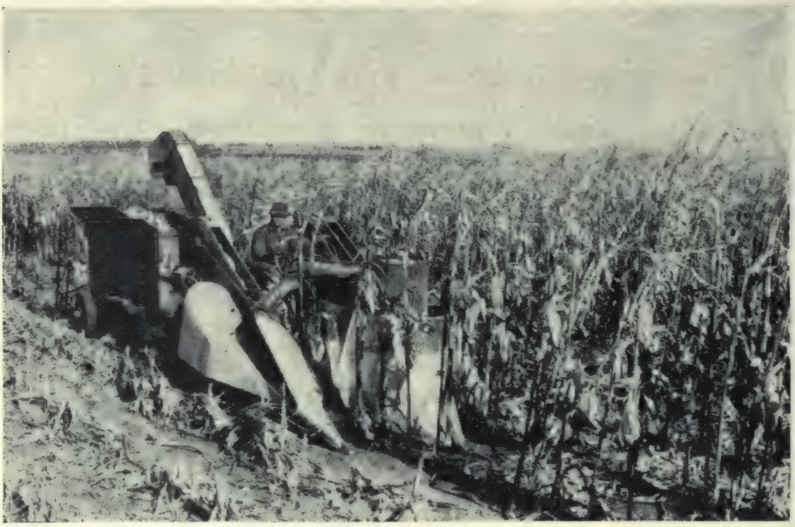

FIGURE 1.—Two-row mounted corn picker.

Two time records of corn harvesting taken in 1937 are given i table 1. The first of these records was taken with a crew of two men one operating the picker (fig. 1) and the other hauling and cribbin the corn (fig. 2). The second record was taken with one man doin the entire job alone by going to the field with a train of three empt wagons coupled behind the tractor on which the picker was mounted picking three loads of corn; and again coupling the three wagon behind the tractor-picker for hauling them to the storage buildin (fig. 3). The picker used in making both of these records was two-row machine mounted on a rubber-tired, general-purpose tracto The wagons had rubber tires, were equipped with telescoping tongue and had capacity of 40 bushels of ear corn each. When operating wit a two-man crew; a pick-up truck was used for towing wagons. A the storage building, the corn was weighed and then unloaded b the inside elevator with dump pit.

The work was done by experienced workmen. They were instructe to avoid any unnecessary loss of time but not to work at more tha normal speed. Soil, weather, and crop conditions were favorable for machine harvesting.

The time records given in table 1 do not include the time required for servicing the equipment, which was 1 to 1½ man hours a day and would add about 10 percent to the labor requirements shown in the table.

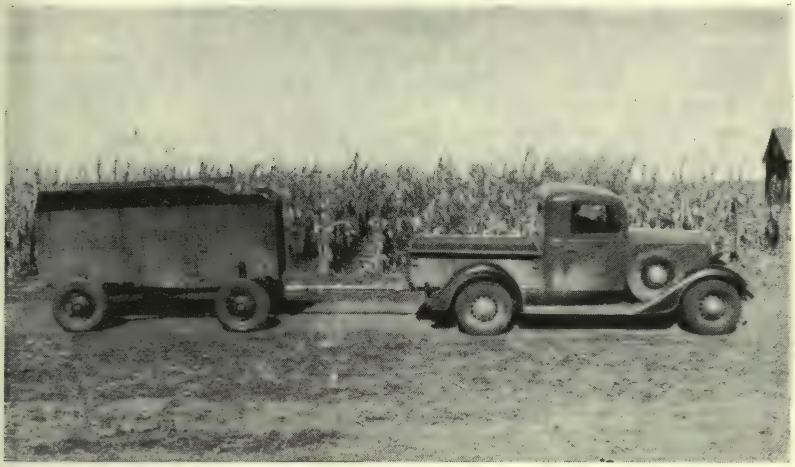

FIGURE 2.—Loaded wagon being towed to storage by light truck.

In estimating the total labor required for the harvest, allowance must be made for taking the picker out of storage at the beginning of the season and putting it back at the end. With a mounted picker this may require 3 or 4 man-days. If a pull-type picker is used, allowance should be made for the labor of hand husking headlands and field openings. When due allowance is made for all miscellaneous harvesting labor and for unfavorable weather, the total labor requirement for harvesting yields of 60 to 70 bushels per acre is likely to be 1½ to 2 man-hours per acre with the best equipment now avail-

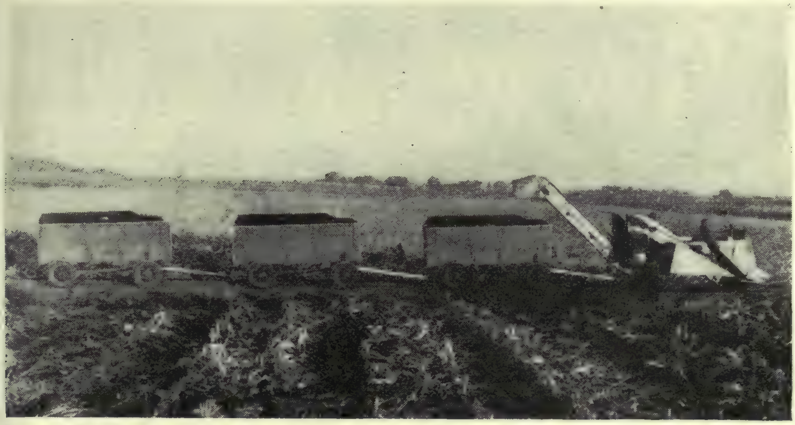

FIGURE 3.—One-man outfit for harvesting and cribbing corn, using two-row mounted picker and three wagons.

able. This is roughly about one-fourth of the labor required for hand husking.

KIND OF CORN ADAPTED TO MACHINE HARVESTING

To the extent that they can be developed without sacrificing yield, the corn-plant characteristics desirable for machine picking are: Stiff stalks to resist storm damage, tough ear shanks to reduce the number of ears that drop off before harvest, large ears, and hard shelling to reduce shelled-corn loss at the snapping rollers. Tough ear shanks tend to increase shelled-corn loss, which limits the advantage to be gained from this characteristic.

To test the adaptability of different kinds of corn to machine harvesting, one open-pollinated variety and three hybrids were planted together, four rows of each, in replicated plots in 1937. Harvesting tests were made on three dates, the results of which are recorded in table 2. The corn designated as A was the Krug variety; B, C, and D were Iowa Agricultural Experiment Station hybrids Nos. 942, 13, and 939 respectively. In the comparison of the quantity of corn left in the field in terms of percentage of total yield, it is observed that hybrid D excelled in each series of tests, the field losses with this hybrid being less than half of those with Krug.

TABLE 2.—*Field losses of four varieties of corn harvested by mechanical pickers in 1937*

Date of test	Kind of corn	Ears on standing stalks	Ears on down stalks	Ears loose on ground	Moisture in shelled corn	Condition of ground	Gleanings per acre							Harvested per acre by picker	Total yield
							Loose ears before picking	Ears after picking	Shelled corn after picking	Gleanings after picking		Total gleanings			
1937		*Percent*	*Percent*	*Percent*	*Percent*		*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Percent of yield*	*Bushels*	*Percent of yield*	*Bushels*	*Bushels*
Oct. 28	A	93.3	5.4	1.3	19.2	Dry	1.05	2.25	0.88	3.13	3.62	4.18	4.83	82.3	86.5
Do	B	97.6	.8	1.6	16.6	do	1.16	.55	2.08	2.63	2.60	3.79	3.74	97.5	101.3
Do	C	100.0	0	0	17.6	do	0	.04	2.53	2.57	2.65	2.57	2.66	94.2	96.8
Do	D	99.0	1.0	0	17.5	do	0	.53	1.18	1.71	1.96	1.71	1.96	85.5	87.2
Nov. 6	A	88.1	6.8	5.1	15.7	do	3.78	5.15	3.74	8.89	9.51	12.67	13.55	80.7	93.4
Do	B	94.3	2.2	3.5	14.0	do	2.24	.82	2.46	3.28	3.60	5.52	6.06	85.6	91.1
Do	C	96.6	1.5	1.9	14.6	do	1.08	3.80	3.90	7.70	7.38	8.78	8.41	95.4	104.2
Do	D	98.5	.5	1.0	15.6	do	.84	.68	1.72	2.40	2.92	3.24	3.94	79.0	82.2
Nov. 26	A	68.6	15.7	15.7	14.3	Frozen	15.3	4.5	3.3	7.8	8.21	23.1	24.35	71.9	95.0
Do	B	91.1	4.0	4.9	13.7	do	4.49	.89	12.20	13.09	13.54	17.58	18.20	79.0	96.6
Do	C	81.1	10.2	8.7	15.0	do	8.87	2.39	5.57	7.96	7.70	16.83	16.30	86.6	103.4
Do	D	87.3	5.3	7.4	14.3	do	4.84	.55	2.93	3.56	4.55	8.30	10.60	69.9	78.2

In the comparison of the yield of corn placed in the wagon by th picker the B and C hybrids were better than D even though som what more corn was left in the field.

There may be opportunity for plant breeders to further improv corn from the standpoint of adaptability to machine harvesting.

FIELD LOSSES

Hand huskers leave some corn in the field, but the amount was nc measured in the Iowa investigations. In the central Indiana exper ments a check was made of corn left by hand huskers in 25 fields i 1930 and in 1931. The smallest quantity left was 0.77 percent and th largest 7.13 percent of the yield. The average left by owners wa 2.05 percent; by hired help, 4.39 percent; and by all, 2.75 percent c the yield.

Table 2 shows the corn left in the field by mechanical pickers i the tests at Ames. These losses are also shown graphically in figure 4 The loss of each kind c corn on October 28 wa below 5 percent, an the loss of hybrid I was below 2 percen Losses increased rapidly in November, especially those of variety A — Krug. Th corn was very dry a the end of Novembe Losses with hybrid I on November 26 wer large on account of eas shelling and consequen excessive loss of shelle corn.

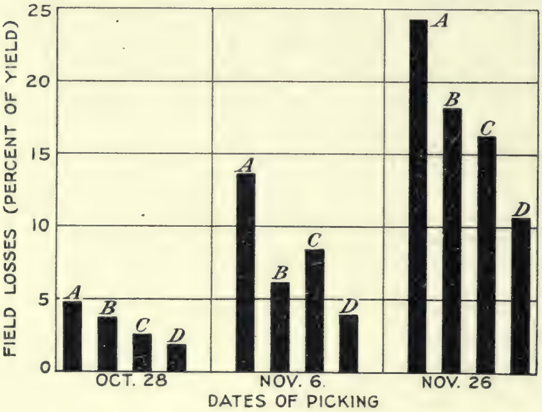

FIGURE 4.—Losses of corn from four varieties on three picking dates.

The field losses in th October tests recorded in table 2 were materially lower than thos shown in previously published results for the years 1931, 1932, an 1933. This improvement is thought to be due largely to the bette condition of the crop in the early part of the 1937 harvesting seasor

HOW TO IMPROVE CORN-PICKER PERFORMANCE

Two important things a farmer can do to keep down field losses i corn-picker operations are: (1) Choose a kind of hybrid corn tha is adapted to machine harvesting and (2) plan operations so tha harvesting will be finished early in November.

It is assumed that the importance of careful operation and prope adjustment of the machine are recognized. Adjustment of snapping rollers should receive special attention as too wide an opening may cause excessive loss of shelled corn.

Investigations at Ames have shown that corn pickers do their bes work early in the season before the crop has become dry and brittl and before it has been damaged by late-fall storms. The progressiv increase in field losses shown in table 2 and figure 4 is the result of November being dry and free from severe storms. Previously published data also show increased losses, as the season progressed.

COORDINATION OF GROWING AND HARVESTING EQUIPMENT

On a farm where corn is cultivated with single-row, horse-drawn cultivators, the logical method of harvesting seems to be hand husking. The acreage grown per man is limited to approximately 40 acres. It is possible for a good hand husker to harvest this acreage without additional help.

If larger teams and two-row cultivators are used, one man may grow about 80 acres. It will then be necessary to hire additional help for harvesting. There will be enough horses on the farm to pull wagons for hand husking, so there is no power problem involved; the only problem is to obtain the necessary extra help.

In case a general-purpose tractor is used for growing the crop, it is not unusual to produce 100 to 150 acres of corn per man and, under some conditions, even larger acreages are handled. Thus the acreage grown per man is sometimes three or four times as much as one man can harvest by hand. Furthermore, on farms where fewer horses are now used for tillage operations, there are not enough on the farm to pull the wagons needed for hand husking. In such cases harvesting by hand becomes a power problem as well as a labor problem, since the farmer must hire both extra men and extra teams. Using a mechanical picker seems to be the logical way to coordinate the labor and power requirements for harvesting and growing the crop where a general-purpose tractor is used for tillage operations.

A TELESCOPING WAGON TONGUE

A telescoping wagon tongue that will save time and labor and practically eliminate the danger of bodily injury in tractor coupling has been employed by the authors of this bulletin in harvesting corn. Time records of the operation of a mounted picker with regular wagon-hitch equipment showed that it took two men to change wagons and the time consumed in changing wagons was 12.7 percent of the operating time. With telescoping tongues (figs. 5 and 6) one man changed wagons without assistance and the time was reduced to 4.5 percent of the operating time. The telescoping tongue can be used with a tractor or with horses.

The tongue is made of two sizes of square steel pipe, the smaller pipe forming the forward part of the tongue and telescoping into the larger pipe, and is equipped with an automatic catch to lock it in the short position. In the extended position, the tongue is the right length for a horse hitch. It may be locked in the extended position by use of a pin through the tongue.

To couple a wagon to a tractor, the operator stops the tractor in position so that its drawbar is within about 4 feet of the end of the wagon tongue; he then gets off, unlatches the tongue, pulls it out to the right length to reach the tractor drawbar, and makes the coupling. Having the tongue coupled in partially extended position, he gets back on the tractor and backs up until the tongue locks in its short position. If the coupling is made with the tongue in a cramped position, it may be necessary to drive ahead and get the wagon straightened out behind the tractor before backing up to latch the tongue In a similar manner one man can easily couple two or more wagon

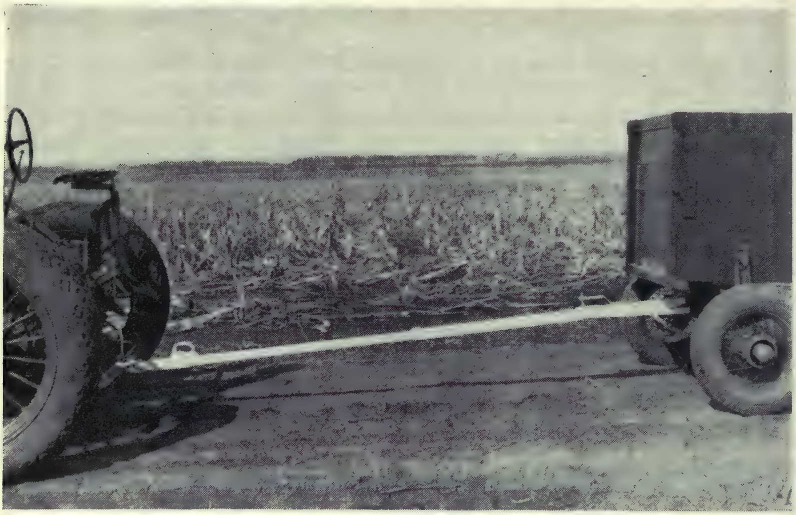

FIGURE 5.—Telescoping wagon tongue in extended position.

in a train when the wagons are equipped with telescoping tongue and with rear drawbar. The practice followed by the authors whe harvesting corn with a one-man crew and mounted picker was t

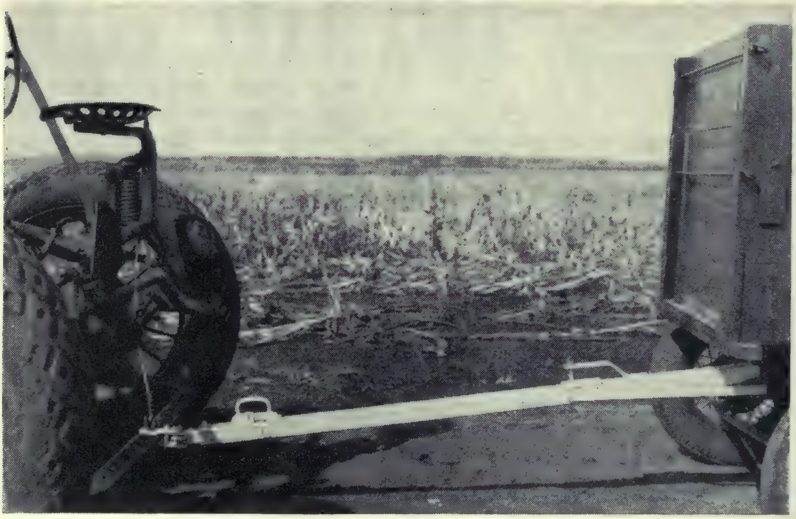

FIGURE 6.—Telescoping wagon tongue in shortened position.

couple three empty wagons in a train behind the tractor when going to the field. Upon reaching the field, the operator dropped off th third wagon at the end of the field and pulled two wagons, picking into the front one until it was filled. He then coupled the rea empty wagon to the tractor and the loaded wagon behind and picked out to the end of the field, where he dropped the loaded wagon and picked up the third empty. When the three wagons were full, he coupled them in a train behind the tractor. The change of wagons was made at whatever point in the field a wagon became full.

By using the new tongue in harvesting corn with a mechanical picker, one man can pick, haul, and crib the crop.

Plans for making the telescoping tongue in a well-equipped shop may be obtained from the Bureau of Agricultural Engineering upon request.

ACCIDENTS

The number of accidents with corn pickers in which men have suffered bodily injury is a matter of concern. Most operators of these machines can and do operate them safely because they take precautions against the several kinds of accidents liable to result through carelessness or failure to recognize the danger points. Safe operation of these machines requires more than usual care.

The following safety suggestions are offered:

1. Before buying a corn picker examine it carefully to see that guards are provided at all points where needed to prevent the operator's clothing from getting caught on shafting, gears, or other moving parts.

2. As the power take-off shaft is a potential danger point, especially on pull-type pickers, it should be provided with good guards to prevent contact with clothing and to prevent the shaft from swinging and striking the operator in case the slip joint should become disconnected while the shaft is in motion. The operator should see that these guards are in place before the picker is started even if it is to be used for only a short run.

The clutch which drives the power take-off should always be disengaged before turning around with a pull-type picker, and with any type of picker it should be disengaged before the operator leaves the tractor seat. It is almost never necessary to leave the seat with the power take-off shaft in motion, but if it is necessary, the operator should use special care to keep himself and his clothing clear of all moving parts.

3. The snapping rollers are built to take in cornstalks, and they cannot be mechanically guarded to prevent accidents in case mittens or hands are carelessly allowed to come in contact with them. The operator must always stay at a safe distance while they are in motion. Efforts to clear clogged rollers should not be made until the power is off. It may be easier to clear them when in motion, but it is too dangerous.

4. The operator's clothing must be free from parts that may easily get caught in gearing or chains or wrap around shafting. This applies to operators of all kinds of power machinery. Overcoat tails, unbuttoned coats, dangling shoestrings, sleeves unbuttoned at the wrist, and gauntlet gloves are all hazards that have led to accidents. A safety precaution is to wear bib overalls or overall suits that cover all other clothing. Boots outside of pant legs are good from the safety standpoint except that laces of lace boots are a hazard if they come untied or if loose ends are not covered.

5. A man's physical condition has much to do with his alertnes and therefore an operator of power equipment needs to take goo care of himself. This is a recognized requirement for safe driving o automobiles and trucks. It is dangerous to operate corn pickers an other power equipment when tired, sleepy, or sick.

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GROWING WHEAT IN THE EASTERN UNITED STATES

FARMERS' BULLETIN No. 1817
U. S. DEPARTMENT OF AGRICULTURE

WHEAT is one of the leading crops of the eastern United States. This region is made up of eastern Texas, eastern Oklahoma, eastern Kansas, southeastern Nebraska, Iowa, southern Wisconsin, and all States to the east, and produces about one-fifth of the country's wheat.

More than 75 distinct varieties of wheat are grown on a commercial scale in this region. Soft red winter varieties predominate, but white winter wheats are grown extensively in New York and Michigan, and hard red winter varieties are grown in Iowa, northern Illinois, northwestern Indiana, and southern Wisconsin, primarily because of their greater winter hardiness.

This wheat is grown largely as a supplement to other crops. It fits well into rotations and serves as an important cover crop to prevent soil erosion and leaching in the late fall, winter, and early spring, when the land would otherwise be bare. It is often grown because it can immediately be converted into cash. In the dairy sections wheat often provides very satisfactory pasture in the fall and winter, and its use for this purpose is increasing. In the Southern States wheat is occasionally grown for hay, especially in those areas where winter oats cannot be depended upon to survive the average winter. In certain years, especially when the hay crop is short, the value of the wheat straw for livestock farmers often approaches that of the grain itself. In addition to serving as roughage in the ration, it is invaluable for bedding and to conserve the value of manure. In many areas wheat is grown for local consumption as flour. There are many small mills throughout the region, and it appears to be desirable in many cases to produce and grind home-grown wheat rather than to ship flour in from distant States.

Wheat is best grown in rotation with other crops. In the region under consideration, suitable varieties, early preparation of the ground, timely seeding with reference to possible damage from the hessian fly, and winterkilling are considerations of primary importance. Commercial fertilizers may often be used to advantage.

This bulletin is a revision of and supersedes Farmers' Bulletins 596, 616, 885, 1168, and 1305.

Washington, D. C. **Issued May 1939**

GROWING WHEAT IN THE EASTERN UNITED STATES

By S. C. Salmon, *principal agronomist*, and J. W. Taylor, *agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry*

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WHEAT IN THE EASTERN UNITED STATES

WHEAT is one of the leading crops of that part of the United States (designated for the purposes of this bulletin as the "eastern United States") composed of the eastern parts of Texas, Oklahoma, and Kansas, southeastern Nebraska, Iowa, southern Wisconsin, and all the States to the east (fig. 1). About one-fifth of the

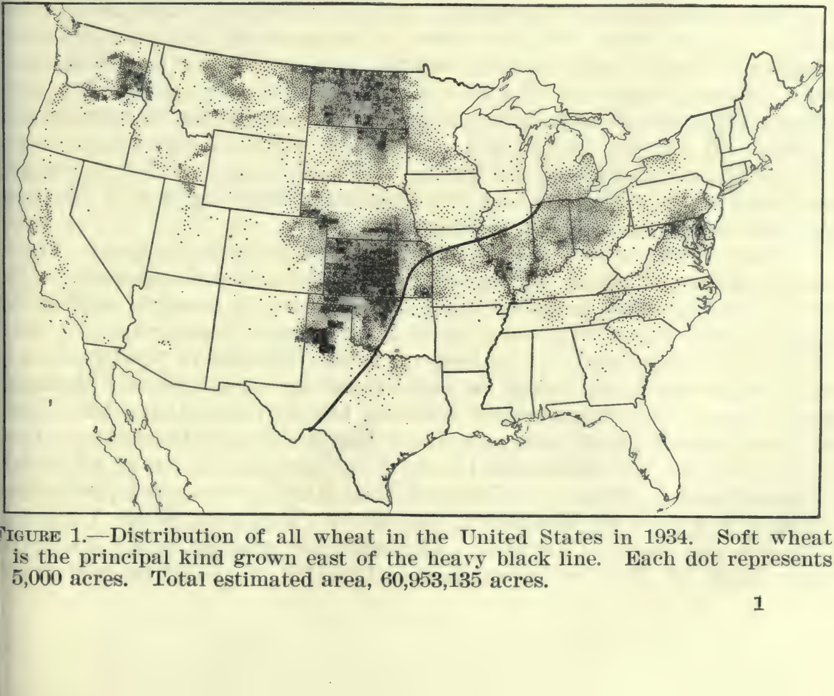


Figure 1.—Distribution of all wheat in the United States in 1934. Soft wheat is the principal kind grown east of the heavy black line. Each dot represents 5,000 acres. Total estimated area, 60,953,135 acres.

total wheat crop of the country is grown in this region, the weste border of which coincides roughly with the line of a 30-inch avera annual precipitation, and nearly all of the region has a precipitati of 30 inches or more. The western boundary also is, in part, based the class and variety of wheat that is grown. Most of the wheat grov is soft red or soft white winter wheat which, in general, is softer texture and lower in protein content than the hard wheats grown the adjoining region on the west. These differences in texture a protein content are due, in part, to variety, but climate, season, a type of soil are also important. The boundary of the soft wint wheat region is somewhat irregular and overlapping as there is sharp line of demarcation between the soft winter, hard winter, a spring wheat regions.

The region under consideration is largely one of diversified ag culture. Dairying, the raising of livestock and poultry, and the pr duction of corn and forage crops are leading industries, and pastu crops are important throughout the region. Cotton is grown exte sively in the South, but wheat is not so well adapted there and grown only to a limited extent.

In most of this region, wheat is grown as a supplement to and rotation with other crops, rather than for the grain itself. It f well into different rotations and serves as an important cover crop retard soil erosion and leaching in the late fall, winter, and ear spring, when the land would otherwise be bare. Most rotations i clude a grass—timothy, for example—and a legume, such as red clove alsike, lespedeza, or sweetclover, either singly or in various combin tions. These can be seeded with the wheat in the fall or in the whe in the late winter or early spring, according to the kind of grass legume, and hence can become established without the loss of a yea time. The soil is protected from erosion and leaching in the mea time.

Wheat is often grown because it can be converted immediately in cash. In the dairy sections wheat often provides very satisfacto pasture in the fall and winter, and its use for this purpose is increa ing. In the Southern States wheat is occasionally grown for ha especially where winter oats cannot be depended upon to survive t winter. When the hay crop is short, the value of the wheat stra often approaches that of the grain. In addition to serving as roug age for livestock, the straw is invaluable for bedding and in conser ing and supplementing the manure.

In many areas wheat is grown for local consumption as flour. The are many small mills throughout the region, and it appears to more desirable and economical, in many cases, to produce and grin home-grown wheat than to ship in flour from distant States.

Most of the wheat of the eastern United States is produced in relatively narrow but irregular belt extending across central Missou and Illinois, including most of Indiana, Ohio, and southern Michiga and southern Pennsylvania, northern Maryland, and Delaware. Le important are the piedmont (foot of the mountain) areas of Nor Carolina and Virginia, and western New York. Scattered producin areas are found in Kentucky, Tennessee, Virginia, West Virgini Georgia, and South Carolina. Although the production of wheat these areas is of little importance nationally, it plays an importa role in the agriculture of these localities, which depends to a considerable extent on how successfully wheat is grown. The best methods and practices for growing wheat, as well as some of the factors that contribute to success, are discussed in this bulletin.

CLIMATE AND SOIL FOR WHEAT

Wheat is adapted to a wide range of climate and soil. It is not well adapted, however, to very warm or moist climates unless there is a comparatively cool, dry season permitting its growth. High rainfall, especially if accompanied by moderate or high temperature, is not generally favorable for wheat because of diseases and difficulties in harvesting and threshing.

In the eastern United States wheat is commonly grown in rotations with corn and clover. Soils capable of producing satisfactory yields of either of these crops are well adapted for wheat. Like other small grains, wheat yields best on fertile, medium- to heavy-textured well-drained soils. In general it is not a satisfactory crop on poor, sandy soils or on poorly drained soils.

KINDS OF WHEAT

Wheat was unknown in North America prior to the discovery of the continent by Columbus in 1492. Hence the varieties that are now grown were introduced from the Old World or are descendants of such varieties. Columbus brought wheat with him from Spain on his voyage to the West Indies in 1494. Whether this particular introduction found its way to what is now the United States is not known, but it is certain that Spanish varieties were later introduced. The early English colonists brought seed with them, as did those from Holland and Sweden. Red May, a variety grown extensively at the present time, probably descended from Red Lammas, a variety grown in England during the seventeenth century and in Virginia prior to the Revolution.

It was traditional for colonists to take seed with them when moving to new countries. Consequently it is more than probable that varieties were introduced into the eastern United States from nearly every country of Europe during the period of colonization. In later years agricultural societies, State and Federal Governments, and especially in recent years the various State agricultural experiment stations and the United States Department of Agriculture have taken an active part in introducing new varieties.

Many of the varieties first brought to the eastern United States proved to be poorly adapted and soon disappeared. Others persisted for a time and were then replaced by better ones. The changes that have been brought about may perhaps be best appreciated from the fact that although no less than 75 distinct varieties are grown in the eastern United States at the present time, less than half a dozen of those in existence 100 years ago are grown today.

During the past 25 years efforts to obtain better varieties have depended mostly on selection and breeding rather than on introduction from foreign countries. Many of the varieties of the present day are a result of these efforts.

Nearly all wheat grown in the eastern United States is seeded the fall and harvested the following spring or early summer. Usual such wheat is known as winter wheat. Varieties of true wint wheat, if sown in the spring, seldom produce heads, or at best on a few heads, and for all practical purposes result in failure. Whe winter wheat will survive the winters, spring wheat is relatively u satisfactory. It usually ripens later and hence is more likely to injured by rust, scab, and other diseases and by unfavorable weath Also, conditions for seeding are usually less satisfactory in the spri than in the fall. The yields of spring wheat usually are much le and the quality is poorer than may reasonably be expected from t better varieties of winter wheat. Spring wheats are occasional grown in the New England States and in the States bordering t Great Lakes, but the acreage is small. Of the total acreage of whe in the eastern United States, only about 0.5 percent is seeded in t spring.

Winter wheat is principally of two classes: hard red winter a soft red winter. More than 90 percent of the wheat grown in t eastern United States is of the latter class. Soft white winter whe is also grown to a limited extent. Hard red winter wheat is gro principally in Kansas, Nebraska, and neighboring States in the Gr Plains. It is so called because of its hard grain, which is high protein. It is especially desirable for bread. The soft winter whe have relatively soft grain, which is low in protein and produ flour best suited for pastries. Excellent bread, however, can made from most varieties of soft wheat and from the flour of blen of soft and hard wheat.

In general, hard wheat is grown in dry, hot climates and on s relatively rich in nitrogen, whereas soft wheat is grown in moi cool climates and on soil relatively poor in nitrogen. When ha wheats are grown in the eastern United States the grain is hard than that of soft wheats, but much softer than when they are gro in the subhumid and semiarid Great Plains. The soft and mottl hard and soft condition of hard wheat kernels is known as yell berry. Such grain usually is less desirable than that produced typical soft varieties. The hard winter wheat varieties are nev theless grown in certain localities because of their superior win hardiness.

CHOOSING A VARIETY

Since many varieties of wheat are grown in the eastern Unit States it is often difficult to decide which are likely to be best a particular State or locality. For example: Is it better to grow red wheat or a white wheat? Do bearded varieties usually yi better than beardless varieties? Should disease resistance be co sidered? Are there important differences in quality, or is it sufficie to know that a given variety can be depended upon to give satisf tory yields? These and other questions merit consideration.

Yield is the characteristic by which a variety is most commo judged. No variety may be considered satisfactory unless it is a to produce a good yield in comparison with others. However, yie ing ability, or the tendency to produce generally satisfactory yie over a period of years, is a difficult characteristic to judge. O reason for this is the great variation in seasons from year to year. Thus, a new variety may produce a very good yield for 2 or 3 years, when it is first introduced, but because of susceptibility to winter-killing or disease, etc., may later prove to be very unsatisfactory. For this reason farmers may well be skeptical of new and untried varieties, especially if extensively advertised and sold at a high price. In general about the only way to determine beyond a doubt whether a given variety is a good yielder is to grow it for a number of years, preferably in comparison with other well-known standard varieties. Usually this can be done most satisfactorily by agricultural experiment stations, where information should be sought if there is doubt as to the worth of a variety.

Much more soft red wheat than soft white wheat is grown in the region under discussion, the relative area in 1934 being about 95 and 5 percent, respectively. Soft white wheat is grown principally in New York and Michigan, where there is a special demand for this class for the manufacture of prepared whole-wheat cereals. In general white wheat runs lower in protein and is more satisfactory for pastries and less desirable for bread than is soft red wheat. Some white varieties are of special value because of their stiff straw and resistance to lodging.

Other things being equal, farmers of the Eastern States prefer beardless (or awnless) varieties. The beards are objectionable in harvesting and threshing, except when a combine harvester-thresher is used, and they also cause sore mouths when the straw is fed to farm animals. In spite of this, about one-third of the wheat produced in the eastern United States is of bearded varieties. Just why this is true has never been completely explained. There is considerable evidence to show that the beards perform important though unknown physiological functions in the final development of the grain, with the result that under some conditions bearded varieties tend to yield more than beardless varieties. In some areas bearded varieties are grown because they are more winter hardy or more resistant to diseases. There is, however, no consistent relation between the presence of beards and yield in the Eastern States, and other varietal characteristics are generally more important. In general it is better to depend upon the performance record of a particular variety than to choose one because it does or does not have beards.

A satisfactory winter wheat must be sufficiently hardy to survive winters of average or more than average severity. Winters fluctuate greatly in this respect. In 1928, for example, Illinois, Indiana, and Ohio lost approximately two-thirds of their acreage of winter wheat by winter-killing, and in 1934 and 1935 the New York crop suffered heavily from the same cause.

Winter-killing in the Eastern States has generally been thought to be due to heaving as a result of the alternate freezing and thawing of the soil in the spring. In this process the plants are lifted above the surface of the ground, and the roots are broken and exposed. The plants may be partially or completely killed. Recently it has been shown that death due to freezing of the plant tissue also occurs. Probably in many cases winter-killing is the combined result of the two.

In general the typical soft winter varieties are most resistant t heaving and least resistant to low temperatures, whereas the har winter varieties are the reverse. Attempts are being made by severa of the State agricultural experiment stations to produce new varietie that possess resistance to both causes of injury, but so far no suc variety that is satisfactory in other respects has been produced.

If conditions are favorable throughout the growing season, lat heading and late-ripening varieties tend to produce the highest yield Such varieties usually tiller more, have a larger leaf surface, an hence are able to use more completely moisture, sunlight, and th elements in the soil to produce grain. Usually, however, condition are not favorable throughout the season. Rust, scab, septoria glume blotch, and other diseases are likely to make their appearan in late spring; and in some areas the high temperatures of earl summer are not the most favorable for growth. On poor soils th supply of mineral elements may be insufficient to carry the crop t maturity in the most satisfactory manner. Late-ripening varieti are also more subject to lodging. For these reasons early-maturin or medium-maturing varieties will usually produce better yields tha those that require a longer growth period. Very early varieties, suc as Gasta and Purplestraw, give the most satisfactory yields in th Coastal Plain as far north as Washington, D. C. In general some what later varieties can be grown in the Northern States, but n where is it advisable to grow very late varieties such as are grow in England, northern France, and Germany.

It is often desirable to grow an early variety in order to get th crop off the land early so that harvest will not interfere with othe farm work or to give a grass or legume crop seeded with the whea an opportunity to develop before hot weather. A difference of even few days at this time of the year may be very important.

The tendency to lodge is a very important consideration in choos ing varieties for this region, especially for soils rich in nitrogen, whe lodging frequently occurs. Lodged grain is difficult and expensi to harvest, and if the lodging occurs before the grain is ripe the fil ing of the heads is interfered with, and a low yield, grain with low test weight, and poor-quality grain are produced.

Varieties differ greatly in lodging. In general the hard winte varieties have weak straw and lodge easily. Most of the soft re varieties have reasonably stiff straw, and the soft white varieties ha very stiff straw. The early varieties, grown extensively in the south eastern United States, have weak straw, but because they ripen earl and have small heads they generally escape serious lodging.

As a general rule varieties which have very stiff straw produce b few tillers and vice versa. This probably has no great practic importance though it may explain why certain varieties, such Genesee Giant and Fultzo-Mediterranean, which have unusually sti straw, do not yield well and are not generally popular.

The most important wheat diseases in the eastern United Stat are bunt or stinking smut, leaf rust, stem rust, loose smut, septor (leaf and glume blotch), and scab (see p. 41). Bunt, or stinkin smut, and loose smut can be prevented by seed treatment; most othe diseases can be controlled only by the use of resistant varieties far as they are available. It is obviously desirable to use such var eties if they are satisfactory in other respects. The resistance of varieties to the various diseases will be discussed in connection with that of each variety.

Soft winter wheat is used mostly for pastry, for general-purpose flour, and for whole-wheat prepared foods. Much of it is ground in small mills and used locally. Quality, insofar as it is determined by variety, receives less consideration than is the case for the hard winter or hard spring wheats grown in the Great Plains. Nevertheless, it should not be ignored in choosing a variety. At times the hard, high-protein wheat of the Great Plains sells at a premium over soft winter wheat, and the question often arises whether high-protein hard wheat cannot and should not be grown in the eastern United States. Some improvement can be made by breeding, but it is certain that wheat from the eastern United States cannot equal that from the drier areas in protein content and quality for bread. There is considerable doubt whether the growing of hard wheat in most of this region would be economically desirable even if feasible.

Some localities produce wheat mostly for their own use as bread. Very soft wheat, as, for example, the soft white varieties, produces a flour that is too weak, that is, too low in protein to make good bread. In such cases it may be more desirable to grow a variety moderately high in protein than to ship in hard winter or hard spring wheat for blending. Such, for example, seems to be the case in certain parts of Michigan where the variety Red Rock is grown.

VARIETIES FOR THE EASTERN UNITED STATES

About 75 distinct varieties of soft winter wheat are now grown on a commercial scale. Some have red, some have white grain; some have beards, and some are beardless. They also vary greatly in color of chaff and straw, in height, and especially in such important practical characteristics as winter hardiness, yield, quality, resistance to disease, time of heading and ripening, tendency to lodge, ability to tiller, etc. Because of the large number of varieties available and their great variation, with respect to these characteristics, the choosing of the best variety is often a difficult matter.

It is impractical to give an adequate description of all of the varieties grown in the eastern United States; consequently, the discussion which follows is limited to the more important ones. For convenience they are arranged in groups according to their resemblance to each other.

SOFT RED VARIETIES WITH BEARDLESS HEADS AND GLABROUS WHITE OR YELLOW CHAFF

The leading varieties of this group are Fultz, Trumbull, Fulhio, Ashland, Purplestraw, Gasta, Leap, Forward, Purkof, Harvest Queen, Flint, and Redhart.

FULTZ

Fultz is grown more extensively than any other variety in the eastern United States (fig. 2). It is one of the older varieties, having been originated in 1862 by Abraham Fultz, who increased it from three heads found in a field of bearded wheat in Mifflin County, Pa. It appears to owe its wide distribution to general all-roun excellence rather than to any particular characteristic. The straw i rather short, moderately stiff, and seldom lodges; the grain is of goo quality, and under average con ditions yields are satisfactory It is grown throughout most o the eastern United States, bu production centers especially i Missouri, southern Illinois, an Indiana and Kentucky. It i grown very little or not at a in Michigan and New Yor and only sparingly in the are extending from northern Illi nois to Pennsylvania, probabl in part because of its lack o winter hardiness and also be cause of the production of su perior varieties which hav replaced it.

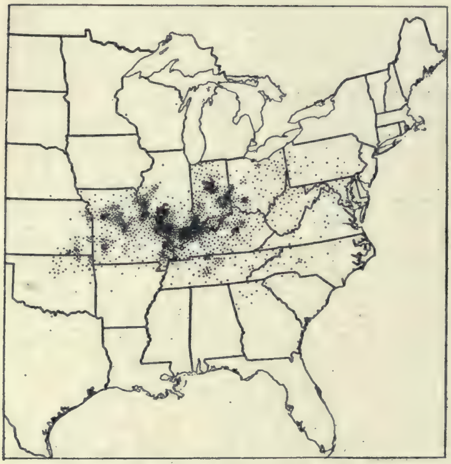


Figure 2.—Distribution of Fultz wheat in 1934. Each dot represents 1,000 acres. Estimated area, 1,870,380 acres.

This variety has slightly in clined, rather tapering heads o medium length and compact ness. The kernels are rathe small and soft and of a pal red color (fig. 3, *B*). The plants are of medium height and matur in midseason. They have a purple or reddish straw when ripe.

Fultz also is grown under many other names, such as Bluesten Bluestem Fultz, Improved Fultz, Jersey Fultz, Tennessee Fultz, an others.

Fultz is recommended for growing in Arkansas, Indiana, Ter nessee, and Virginia by the agricultural experiment stations of thos States.

TRUMBULL

Trumbull, a selection from Fultz made at the Ohio Agricultura Experiment Station, has a taller, stiffer straw and in Ohio ha yielded somewhat better than Fultz. The straw is a very ligh purple, and the heads are more erect than those of the parent. In recent years, it has increased rapidly in Ohio and now accounts for more than half the wheat acreage of that State (fig. 4). Like Fultz, it is somewhat deficient in winter hardiness. It is also somewhat resistant to loose smut. Trumbull is especially recommended for western Ohio.

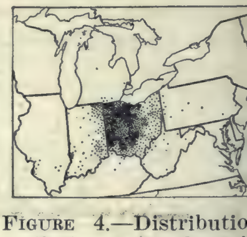


Figure 4.—Distributio of Trumbull wheat i 1934. Estimated are 1,135,641 acres.

FULHIO

Fulhio also is a selection from Fultz made at the Ohio station and in appearance (fig. 3, *A*) is very similar to the parent variety. It is grown extensively in eastern Ohio and to a considerable extent i southern Illinois (fig. 5). In Ohio it appears to be somewhat mor susceptible to loose smut and scab and has somewhat weaker stra

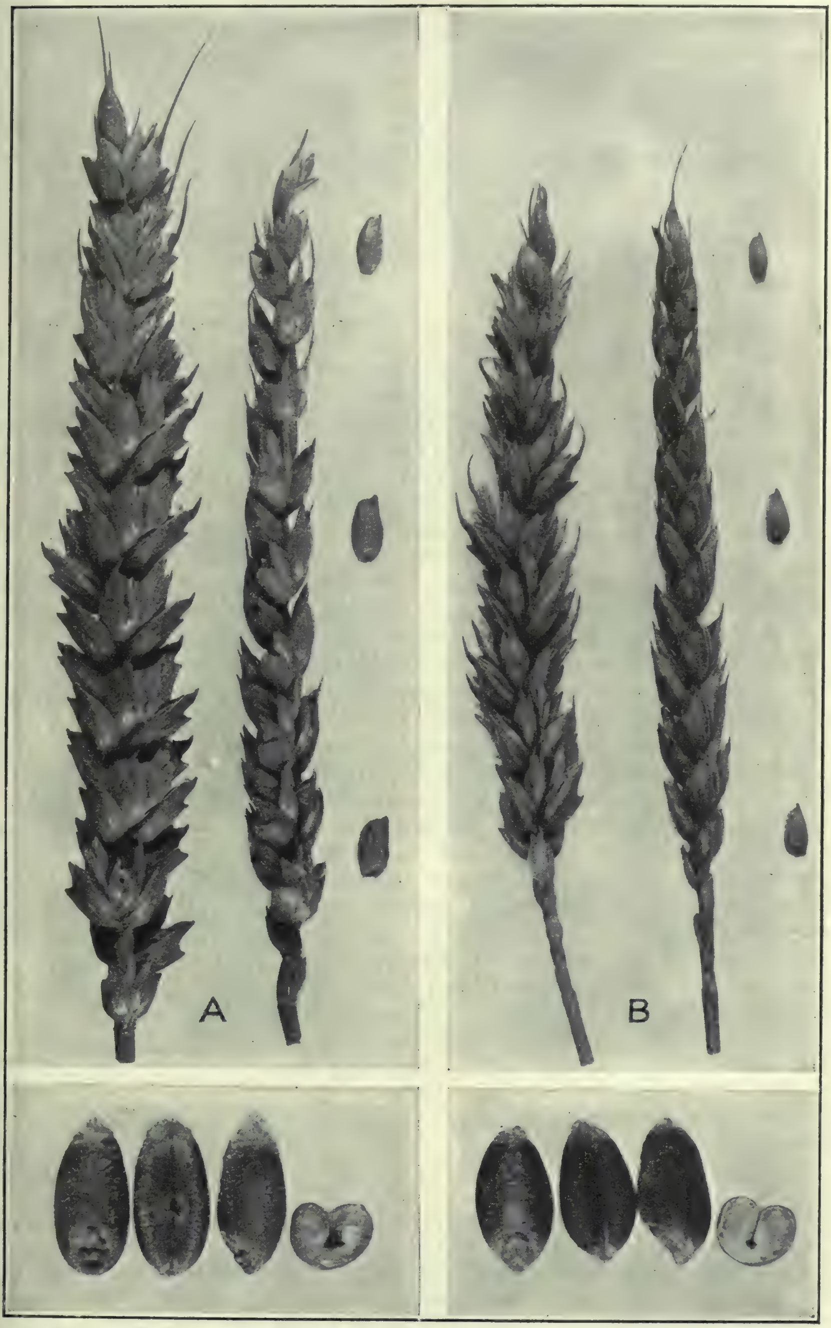


FIGURE 3.—Heads and grain of Fulhio (A) and Fultz (B) wheats.

than Trumbull, although better than Fultz. Otherwise it has al the good points of Trumbull and is somewhat more winter hardy The Ohio station recommends it for eastern and especially northeastern Ohio.

ASHLAND

Ashland is a selection from Fultz made at the Kentucky Agricultural Experiment Station. It was first released for commercial growing in 1919 and is grown in Kentucky to a limited extent. The straw is stronger than that o Fultz, and the variety is claimed to be somewhat resistant to scab.

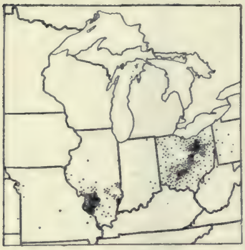


FIGURE 5.—Distribution of Fulhio wheat in 1934. Estimated area, 533,838 acres.

PURPLESTRAW

Purplestraw heads and ripens early. It i the leading variety along the lower Piedmont and the Coastal Plain from Virginia south (fig. 6). It is the leading variety in Georgia and South Carolina and the third most important in North Carolina. In this area its early maturity is a decided advantage in enabling it to escape damage from leaf rust and the high temperatures of early summer.

The variety tillers freely and has rather fine straw. Unlike other winter varieties under average conditions, it will head and produce a fair crop in a normal manner when sown early in the spring. The variety is one of the least winter hardy of the soft winter wheats and for this reason should not be grown north of Washington, D. C., nor at high altitudes south of Washington.

The observable head and grain characters of Purplestraw (fig 7, *B*) somewhat resemble Fultz (fig. 3, *B*). The heads are shorter than Fultz, erect, and rather compact, and they have short-tip awns. The kernels are small, pale red, very soft, and of excellent quality for pastries. The straw, as the name implies, is generally purple or purplish in color.

Purplestraw is one of the oldest varieties in the United States, its known history extending back more than 100 years. Probably because of its long history in this country, it is known by a number of names, including Alabama Bluestem, Bluestem, Georgia Bluestem, Georgia Red, and Ripley.

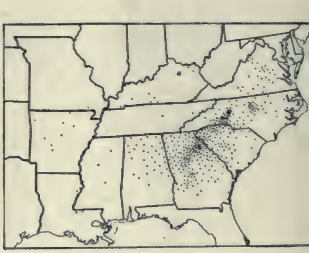


FIGURE 6.—Distribution of Purplestraw wheat in 1934 Estimated area, 306,028 acres.

GASTA

Gasta is a selection from Purplestraw made at the Georgia Experiment Station. It has recently been distributed to farmers for growing in that State. In experimental trials at the Georgia station, it has produced higher yields than Purplestraw, and has been more resistant to loose smut. It is very early maturing and also resembles the parent in other respects.

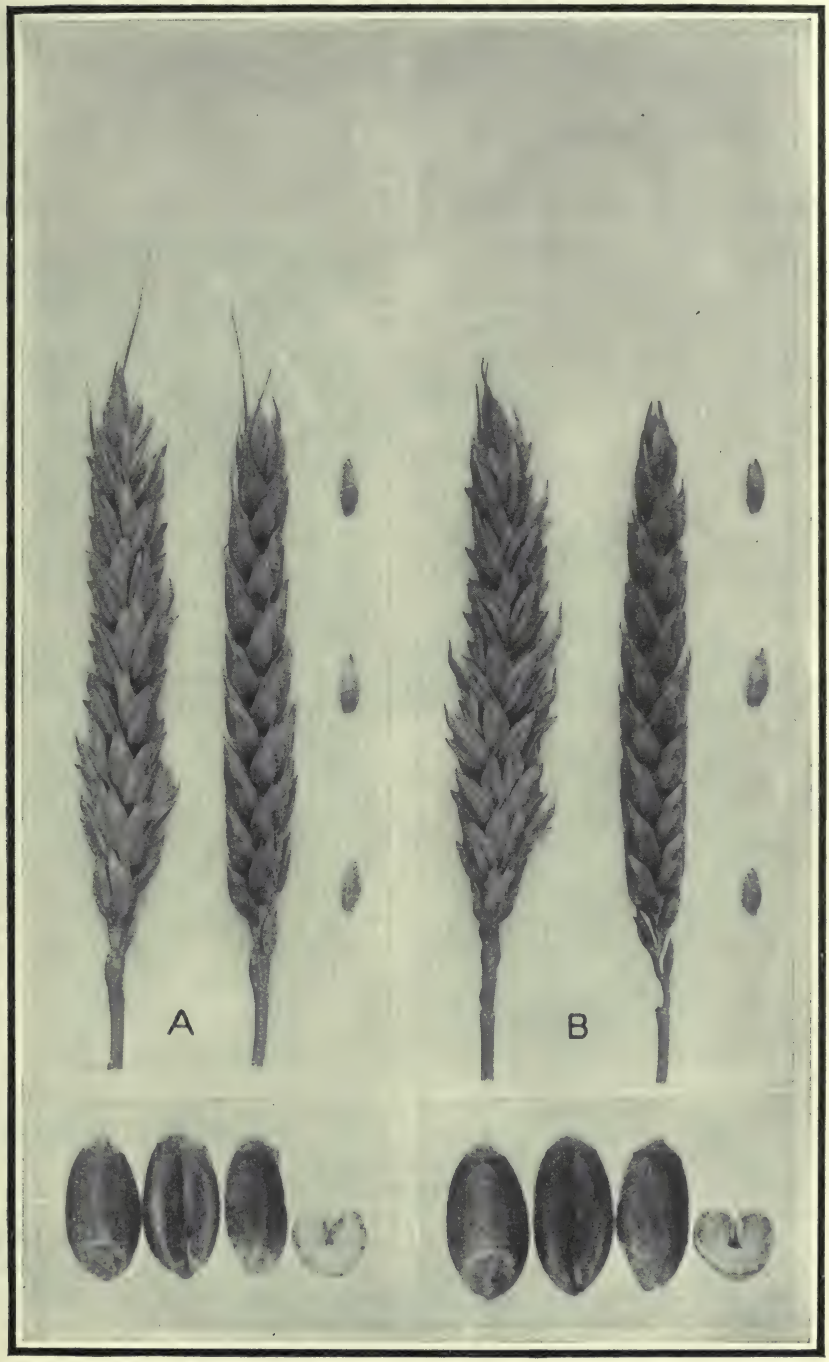


FIGURE 7.—Heads and grain of Flint (*A*) and Purplestraw (*B*) wheats.

LEAP

Leap is one of the leading varieties in southeastern Pennsylvania, northern Maryland, and Delaware (fig. 8). It is also grown in North Carolina, Virginia, and other South Atlantic States. Good quality of grain, satisfactory yields, a reasonably strong straw, and the fact that it is beardless apparently account for its popularity. It is distinctly defective in winter hardiness and should not be grown north of the area where it is now found.

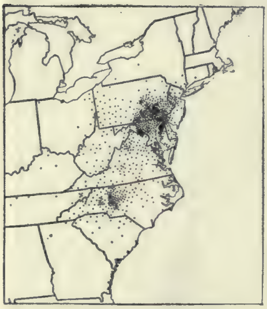


FIGURE 8.—Distribution of Leap wheat in 1934. Estimated area, 708,903 acres.

The variety can usually be distinguished from other beardless varieties by its yellow straw, the rather long, lax, tapering, and nodding heads, and by the brownish stripes on the chaff, which give the head a yellowish appearance (fig. 9, *A*). It is recommended for growing in Pennsylvania, New Jersey, Virginia, Maryland, and North Carolina by the agricultural experiment stations of those States.

FORWARD

Forward was originated from a beardless plant found in the bearded variety Fulcaster at the New York (Cornell) Agricultural Experiment Station. It was first distributed in 1920. It has been one of the highest-yielding varieties in New York and in recent years has found its way across Pennsylvania into northern Maryland and Virginia (fig. 10). It is grown, especially, in southeastern Pennsylvania. It is more winter hardy than Purplestraw or Leap, being approximately as hardy as Fulcaster or Fultz. It has short, stiff straw which does not lodge easily. It has not been especially popular in New York because of its red grain; white-kerneled varieties are preferred in that State. It has recently been increasing in acreage, probably because of its superior winter hardiness, and is recommended for growing in New York, Pennsylvania, and Virginia.

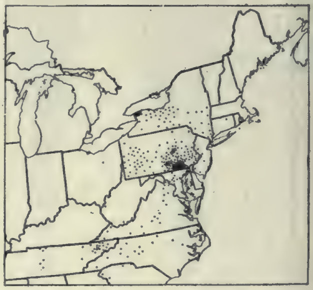


FIGURE 10.—Distribution of Forward wheat in 1934. Estimated area, 258,329 acres.

PURKOF

Purkof is usually classed as a soft red winter wheat, although it often produces rather hard or semihard kernels and on the market is sometimes classed as a mixed wheat. Heads and grain of this variety are illustrated in figure 9, *B*. The variety was produced by the Purdue University Agricultural Experiment Station from a cross between Red May (Michigan Amber) and Malakof and was distributed to farmers by that station. It is grown principally in Indiana but in recent years has found its way into Illinois and western Pennsylvania (fig. 11).

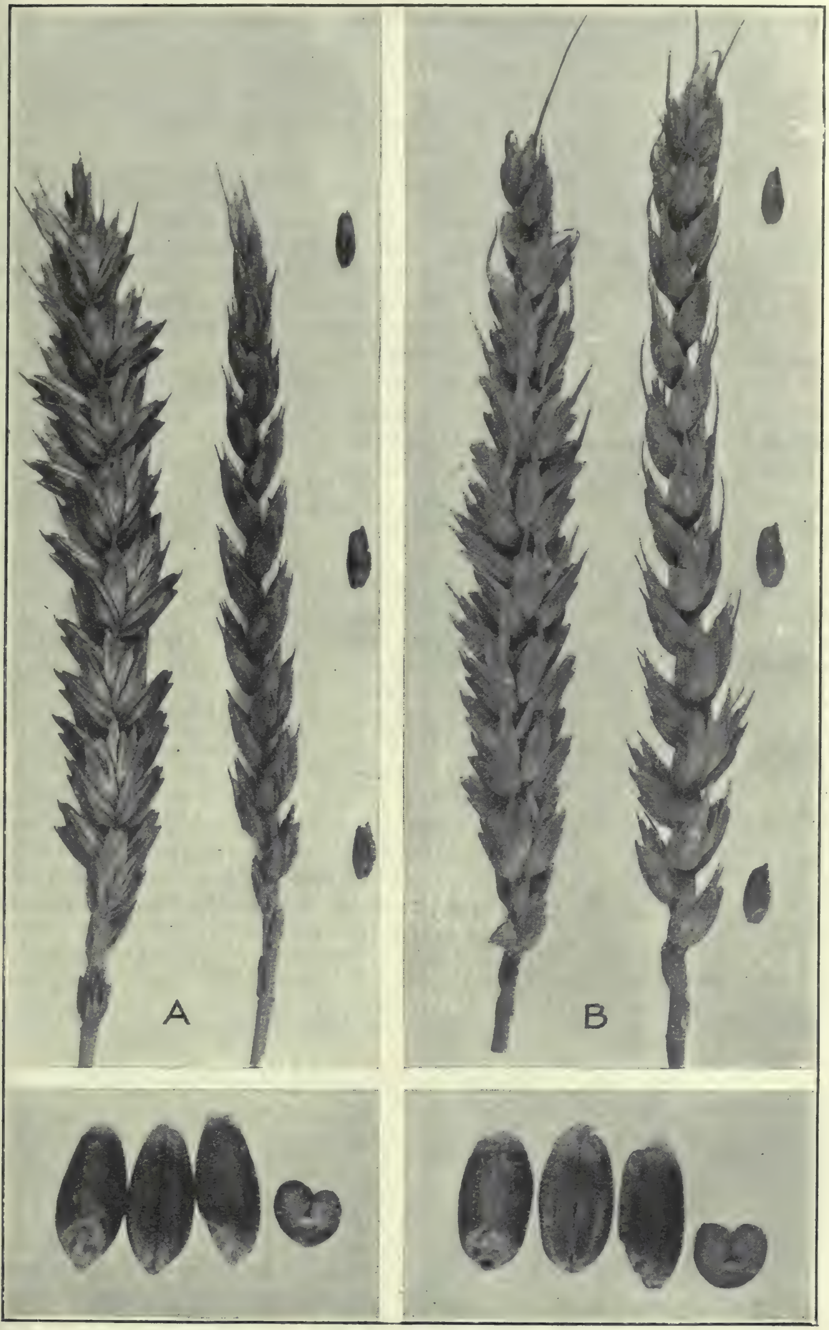


FIGURE 9.—Heads and grain of Leap (*A*) and Purkof (*B*) wheats.

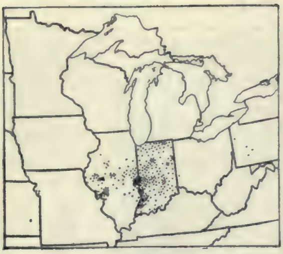


FIGURE 11.—Distribution of Purkof wheat in 1934. Estimated area, 300,357 acres.

The variety is one of the most winter hardy of the soft wheats and no doubt largely for this reason has given relatively high yields. It has been somewhat in disfavor by soft-wheat millers because of its tendency to produce hard or semihard grain.

HARVEST QUEEN

Harvest Queen is a moderately old variety, having been produced from a single plant found in a field of another variety by E. S. Marshall, of De Soto, Kans., in 1895. It was distributed locally by Mr. Marshall and at the present time is grown in northeastern Kansas and in a small area in south-central Kansas and the adjoining portion of Oklahoma, and to some extent in Missouri (fig. 12). It has been grown experimentally farther east, but, in general, has not given satisfactory yields.

This variety is one of the most winter hardy of the commercial soft winter wheats. This in a large measure accounts for its production in northeastern Kansas. It has stiff, strong straw, but nevertheless sometimes lodges owing, no doubt, to the fact that it grows rather tall. The variety is susceptible to flag smut, a disease found in limited areas in eastern Kansas and central Illinois, but strains resistant to this disease have recently been isolated. Heads and grain of this variety are illustrated in figure 13.

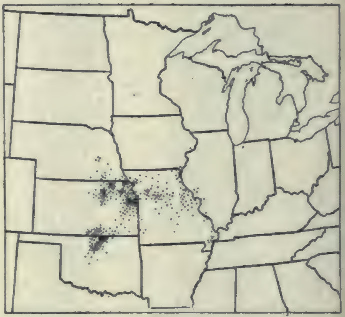


FIGURE 12.—Distribution of Harvest Queen wheat in 1934. Estimated area, 379,897 acres.

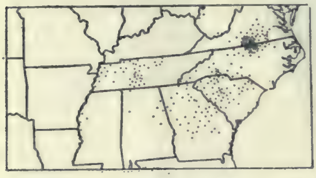


FIGURE 14.—Distribution of Flint wheat in 1934. Estimated area, 178,020 acres.

FLINT

Flint, an old variety of unknown origin, is grown in south-central Virginia and the contiguous area in north-central North Carolina and in South Carolina, and sparingly elsewhere in the southern part of the soft red winter wheat belt (fig. 14). The variety is generally known as Red May, though very different from the variety grown under that name in the North-Central States. (See p. 19 and fig. 20.) The name Early May is also commonly used for this variety. It is about as early in maturity as Purplestraw.

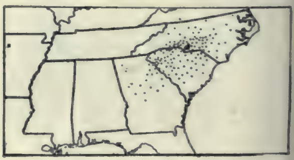


FIGURE 15.—Distribution of Redheart wheat in 1934. Estimated area, 112,392 acres.

REDHART

Redhart is a selection from Flint and is widely grown in North Carolina and South Carolina (fig. 15). It is early and has stiff white straw. The kernels are red and soft. It is less winter hardy than other varieties of winter wheat and should not be grown where winter injury is likely to occur. The variety is recommended for growing in North Carolina and South Carolina.

SOFT RED VARIETIES WITH BEARDLESS HEADS AND GLABROUS BROWN OR RED CHAFF

This group differs from the previous group in having brown or red instead of white or yellow chaff. The heads are smooth and beardless and the kernels red. The leading varieties are Poole, Red Wave, Red May, Currell, and Baldrock.

POOLE

Poole has been one of the important varieties of wheat in Indiana and Ohio for about 50 years and is still grown to a considerable extent, although new varieties in recent years have tended to crowd it out (fig. 16). It has been widely recommended as a high-yielding variety for most of the area that grows soft red winter wheat, but at present is not extensively grown outside of the States mentioned. It appears to be about average in winter hardiness, stiffness of straw, and time of maturity. The beardless heads with brown smooth chaff are wide, flattened, and very nodding (fig. 17, *B*); the straw is purple and of medium height, and the kernels are soft and of

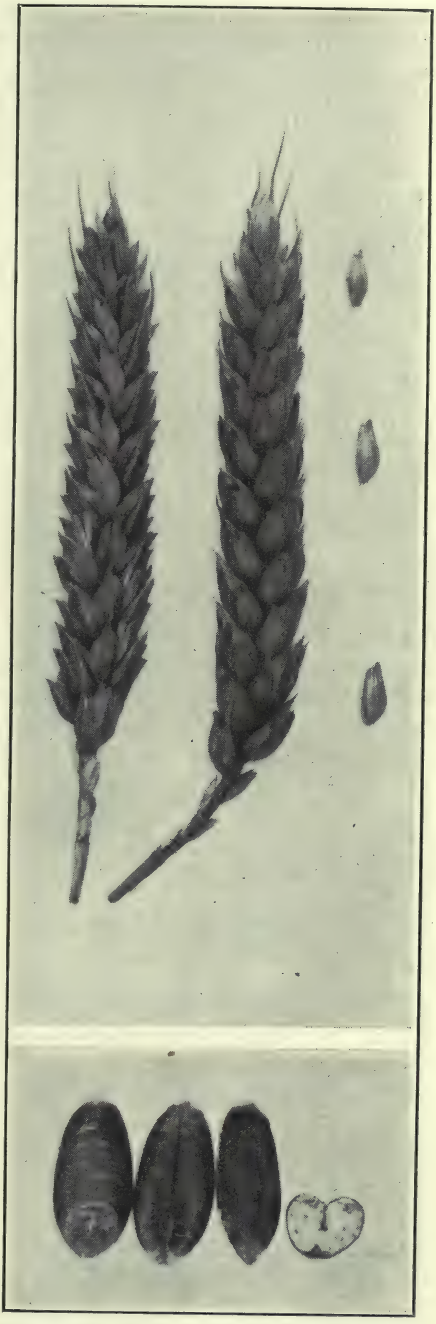


FIGURE 13.—Heads and grain of Harvest Queen wheat.

medium size. In milling and bread-baking quality Poole is considered one of the best of the soft wheats.

Poole is grown under a variety of names, including Bluestem, Gill, Harvest King, Kentucky Bluestem, Nissley, Ocean Wave, Red Amber, Red Chaff, Red Fultz, Red King, Red Russell, Royal Red Clawson, Wagner, Winter King, and others. Poole is recommended for Missouri and Indiana.

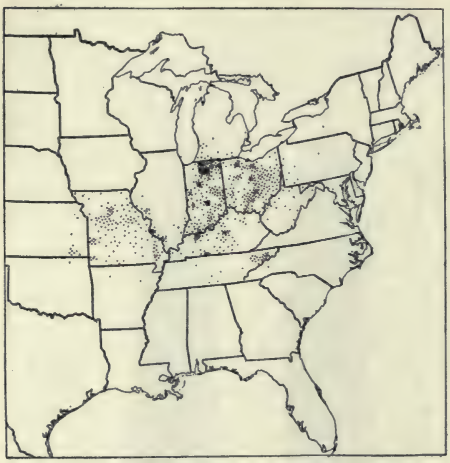


FIGURE 16.—Distribution of Poole wheat in 1934. Estimated area, 672,564 acres.

RED WAVE

Red Wave occupies approximately the same area as Poole (fig. 18). In appearance it is very similar to Poole, except that it has white straw, whereas the latter has purple straw and slightly darker chaff (fig. 19, p. 18). It appears to have somewhat stiffer straw than Poole, but in experimental trials it has been distinctly inferior to most varieties in bread-making quality. Except, possibly, for showing less tendency to lodge, Red Wave appears to have no qualities of special merit not possessed by many other varieties of soft wheat. It is not recommended for growing in any State.

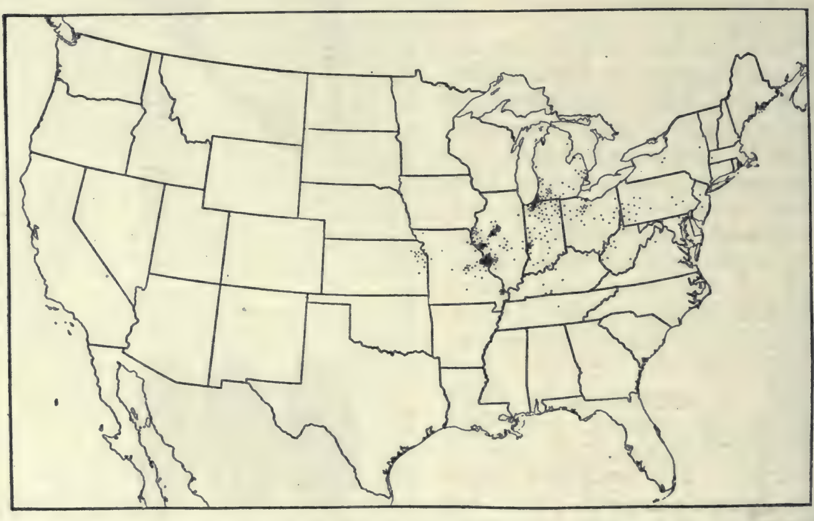


FIGURE 18.—Distribution of Red Wave wheat in 1934. Estimated area, 307,259 acres.

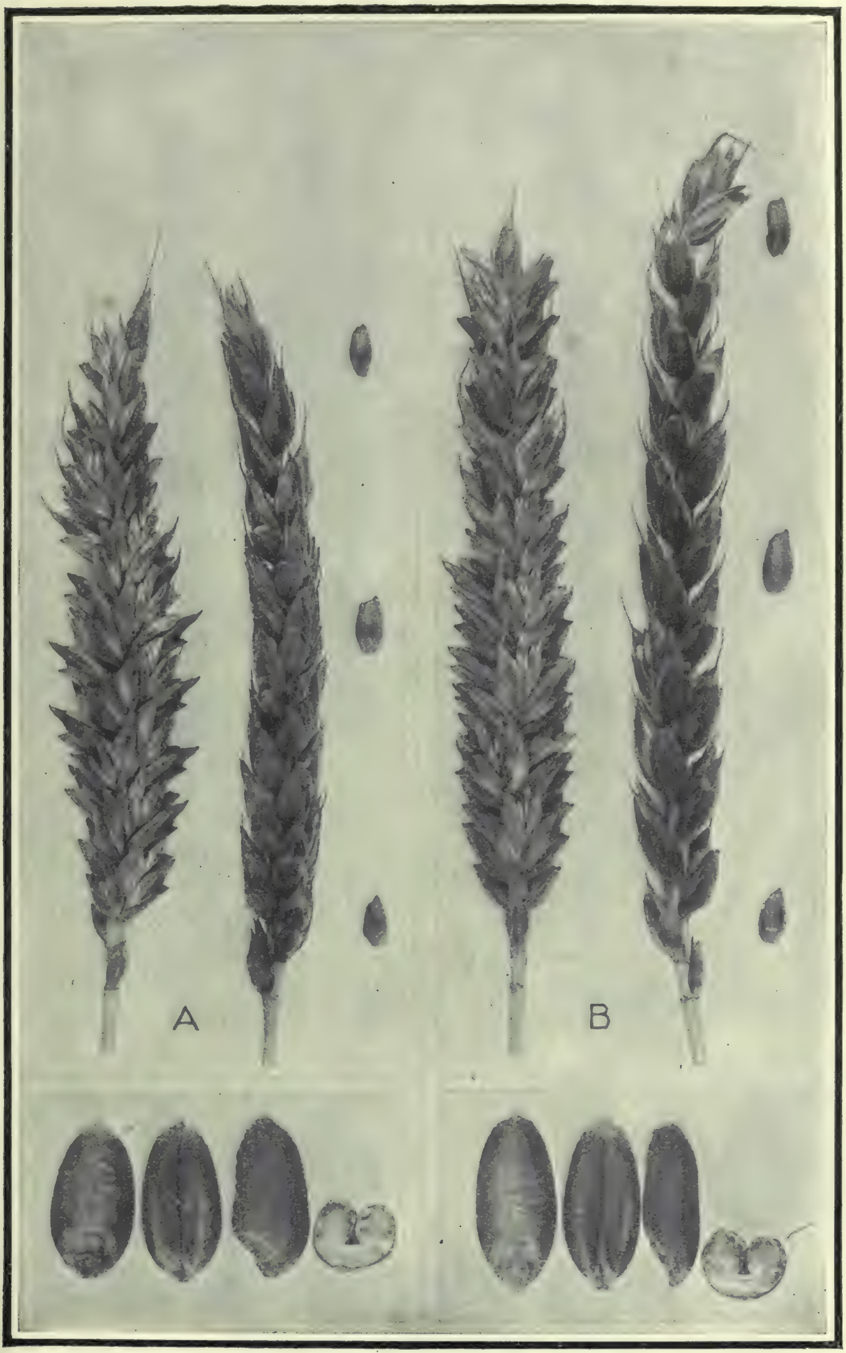


FIGURE 17.—Heads and grain of Currell (*A*) and Poole (*B*) wheats.

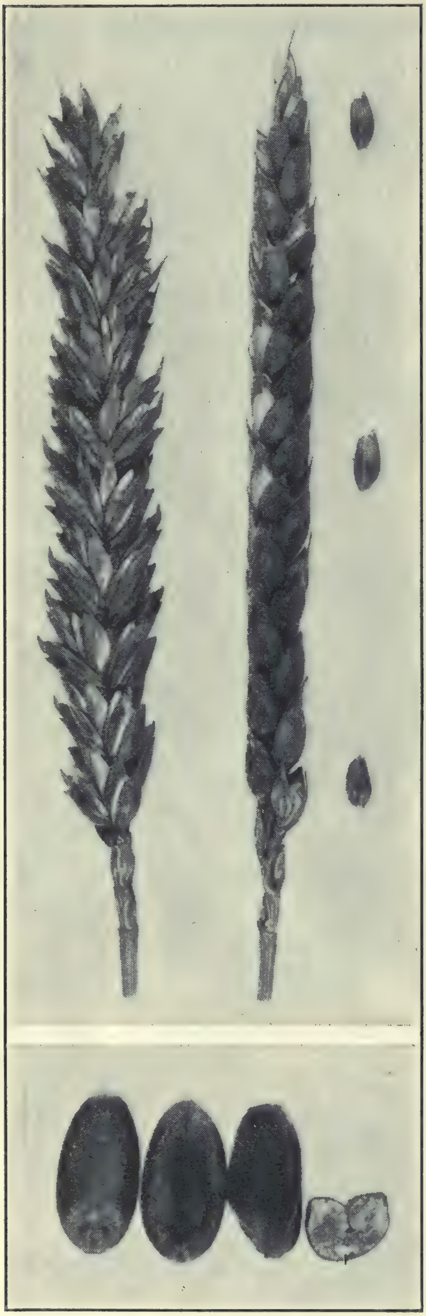


FIGURE 19.—Heads and grain of Red Wave wheat.

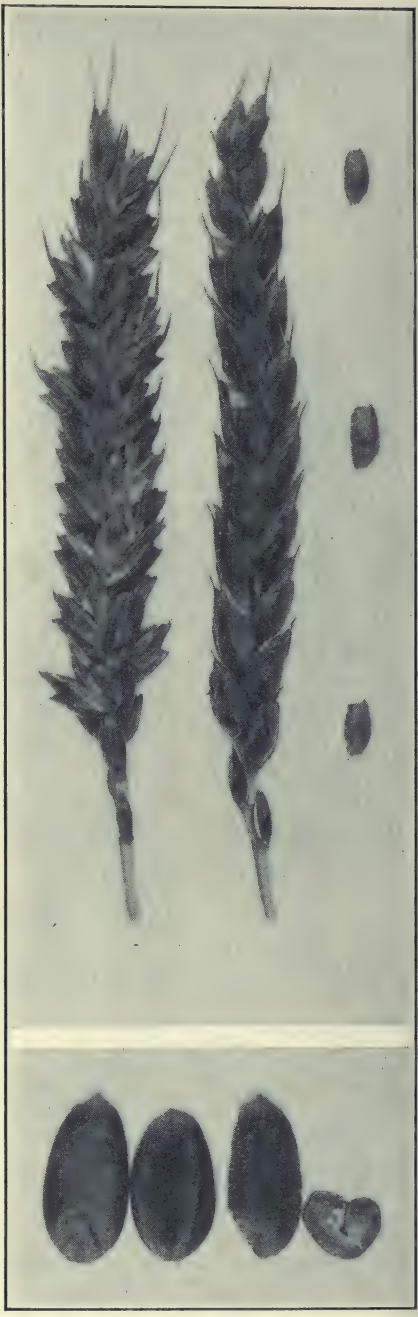


FIGURE 20.—Heads and grain of Red May (Michigan Amber).

RED MAY

Red May (Michigan Amber) is one of the leading varieties in ndiana, being second only to Fultz. It is grown extensively in llinois as Michigan Amber and in Missouri as Michigan Wonder fig. 21). The variety has been grown extensively since 1845 as ed May, whereas the names Michigan Amber and Michigan Wonder re of recent origin. The older ame is used in the present disussion. It has been grown ather extensively throughout ost of the soft red winter wheat rea but in recent years has been onfined for the most part to ndiana, Illinois, Missouri, and djoining States. It is earlier han Poole, which it closely reembles in other respects, and is ore winter hardy. The appearnce of the head and grain is hown in figure 20. Its history as been traced back to the Red ammas or Yellow Lammas rown in Europe during the eventeenth century. Red May is recommended for growing in ndiana, Illinois, and Missouri.

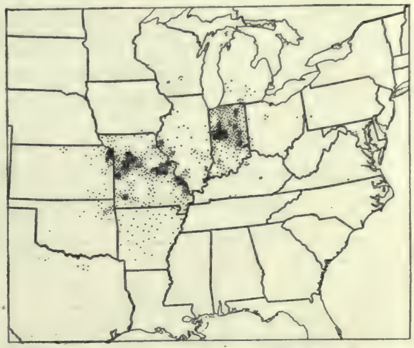
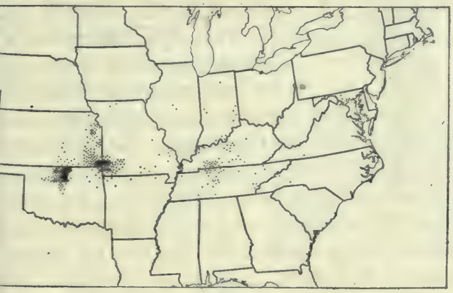


FIGURE 21.—Distribution of Red May (Michigan Amber) wheat in 1934. Estimated area, 977,421 acres.

CURRELL

Currell or Currell Prolific differs from most other varieties of this roup in being earlier. It also has rather short straw, which, comined with its stiffness, renders it quite resistant to lodging. The ariety is rather widely distributed (fig. 22), especially along the southern border of the soft wheat belt, but is not extensively grown in any area with the exception of southern Kansas, north-central Oklahoma, and southeastern Missouri. Its early maturity, resistance to lodging, satisfactory yield, and excellent quality for pastry flour make it a popular variety in this area. A definite lack of winter hardiness prevents its being grown very far north. The variety is also known as ill, Golden Chaff, Pearl Prolific, Red Odessa, Red Prolific, and ennessee Prolific. The heads and grain of this variety are illusrated in figure 17, *A*. Currell is recommended for Maryland and entucky. In the latter State it is known as Kentucky 47.



IGURE 22.—Distribution of Currell wheat in 1934. Estimated area, 480,478 acres.

BALDROCK

Baldrock is a variety produced by the Michigan Agricultural Experiment Station, East Lansing, Mich., from a field hybrid between

Red Rock and some unknown variety. Unlike the known parent it is beardless. It was first distributed to farmers in 1931. In Michigan it has produced higher yields than other varieties, has stif straw, and is more winter hardy than Red Rock. It is recommende for Michigan.

SOFT RED VARIETIES WITH BEARDED HEADS AND GLABROUS WHITE OR YELLOW CHAFF

The varieties of this group resemble those of the first group, except that they have bearded heads. The following six varieties an selections of commercial importance are discussed: Fulcaster, Nittany, V. P. I. 131, Mammoth Red, Rudy, and Kawvale.

FULCASTER

Fulcaster is second only to Fultz of all varieties of soft wheat i acreage in the eastern United States (fig. 23). Fultz owes much o its popularity to th fact that it is beardless Fulcaster, however, i grown chiefly becaus of its very satisfactor yields, although, othe things being equal farmers prefer a beardless variety. No variet excels it in this respect over so large territory and unde such variable conditions. It is grown especially in the piedmont area from Pennsylvania and norther Maryland, south t North Carolina an Tennessee, but it is als of commercial importance in 25 States included in the region that extends from Kansas an Oklahoma to Delaware and from Michigan to Georgia. Throughou this region, it frequently is found among the highest yielding varieties. Just why this is, has never been explained. Probably its relatively high degree of winter hardiness as compared with that of mos soft wheats, its medium-early maturity, a moderate degree of resistance to certain diseases, and perhaps the fact that it is bearded ar the principal reasons.

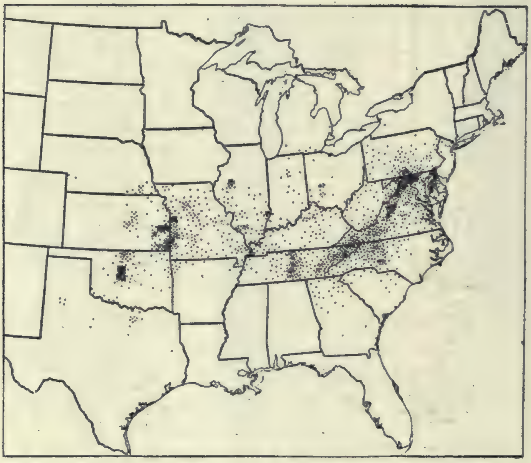


FIGURE 23.—Distribution of Fulcaster wheat in 1934. Estimated area, 1,395,122 acres.

Fulcaster has been grown under a variety of names. A few o the more important in use at the present time are Bearded Bluestem, Bearded Purplestraw, Dietz, Dietz Longberry, Georgia Red Lancaster, Red Wonder, Stoner, Forty-to-One, Half Bushel, Kentucky Wonder, Marvelous, and Miracle. Several of these names ar used also for other varieties of wheat.

Fulcaster is reported to have originated in 1886 from a cross between Fultz and Lancaster (Mediterranean) made by S. M. Schindel of Hagerstown, Md. In 1884, 2 years prior to the date mentione above, Dietz Longberry, which is identical with Fulcaster, was ob

ined from George A. Dietz, of Chambersburg, Pa., by the Ohio
.gricultural Experiment Station. The true origin of Fulcaster,
ierefore, is rather doubtful, but it probably is an older variety than
iese facts indicate. The variety has been exploited on several occa-
.ons by firms who made extravagant claims concerning its ability
) produce high yields with a low rate of seeding. Names such as
Iiracle, One-Peck-
o-the-Acre, and
Iillennium were
ius applied to cer-
ain strains of Ful-
aster. It is now
nown that Ful-
aster and strains of
iis type should be
own at the same
ate as other vari-
ties.

Fulcaster has
ather large, bearded,
apering, inclined
eads and white
haff with brownish-
ellow stripes (fig.
4). The beaks
points on the outer
haff) are less than
ne-third of an inch
i length. The
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'he kernels are mod-
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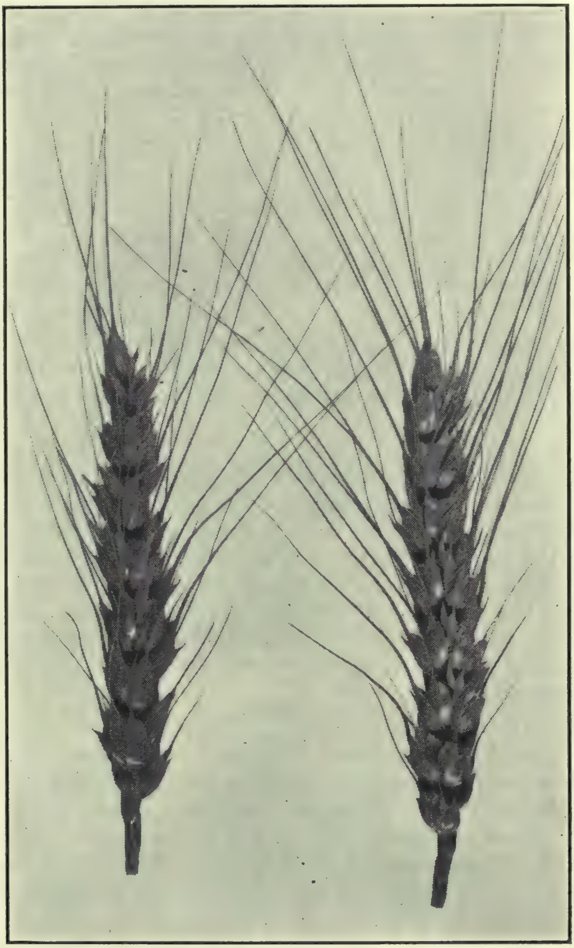


FIGURE 24.—Heads of Fulcaster, the leading bearded wheat of the eastern United States.

In milling and
aking quality for
read, Fulcaster ranks with the better varieties of soft red winter
heat. Under favorable but dry conditions in Kansas, Texas, and
)klahoma it is nearly equal in quality to hard red winter varieties
or bread. Fulcaster is a recommended variety for North Carolina,
'ennessee, Virginia, West Virginia, Illinois, Missouri, Oklahoma,
Cansas, Kentucky, Georgia, and Arkansas.

NITTANY

Nittany is a selection from Fulcaster made at the Pennsylvani Agricultural Experiment Station and was first distributed to farmer in 1918. It is taller, ripens several day later, and under favorable conditions wil produce somewhat larger yields than th parent. However, it is somewhat more inclined to lodge on rich land than is th parent variety. It is grown especially i Pennsylvania and Delaware (fig. 25).

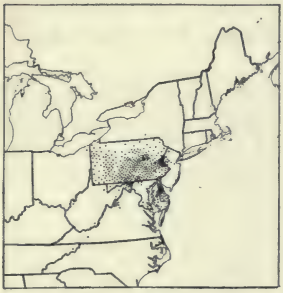


FIGURE 25.—Distribution of Nittany wheat in 1934. Estimated area, 409,223 acres.

V. P. I. 131

V. P. I. 131 is a selection from Fulcaste made by the Virginia Agricultural Experiment Station. It is the third most important variety in Virginia, being exceeded i acreage only by Fulcaster and Leap. It ha been reported from Tennessee, North Carolina, and West Virginia, but is not grown extensively in those State (fig. 26). It closely resembles Fulcaster in appearance and growt It is especially recommended for growing in Virginia.

MAMMOTH RED

The history of Mammoth Red extends back to the early nineties when it was distributed by a seed company in Dallas, Tex., and presumably was grown in Texas. At the present time it is scarcely grown, except on the Eastern Shore of Maryland and in adjacent Delaware, where it has become an important variety in the past 10 years. The variety is very similar to Fulcaster but matures later, and the kernels are somewhat larger and harder.

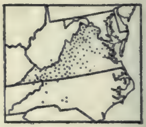


FIGURE 26.—Distribution of P. I. 131 whea in 1934. Estimated area 106,292 acres.

RUDY

Rudy is also one of the older varieties of wheat, the importance of which has been declining in recent years. It was originated at Troy, Ohio, in 1871 and was a leading variety in the Ohio River Valley for many years. It present acreage probably is less than half of what it was 15 year ago. It is grown and recommended chiefly in Indiana (fig. 27). Th variety usually can be distinguished from others of this group b the yellowish-white chaff with black-striped margins.

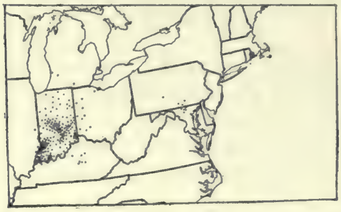


FIGURE 27.—Distribution of Rudy wheat in 1934. Estimated area, 211,991 acres.

KAWVALE

Kawvale was developed at the Kansa Agricultural Experiment Station as selection from an old variety known a Indiana Swamp. It was released fo distribution to Kansas farmers in 1932 The variety is resistant to winter injur as compared with other soft wheats an is unusual in being highly resistant t certain strains or varieties of hessian fly

It is also resistant to leaf rust. It matures early and gives high yields. Unfortunately, the grain shatters easily and cannot be allowed to stand in the field after it is ripe. While the variety is classed as soft red winter, the grain usually can better be described as semihard. It is recommended in Kansas.

SOFT RED VARIETIES WITH BEARDED HEADS AND GLABROUS BROWN OR RED CHAFF

Only three varieties of commercial importance are included in this group. They are Mediterranean, Denton, and Red Rock.

MEDITERRANEAN

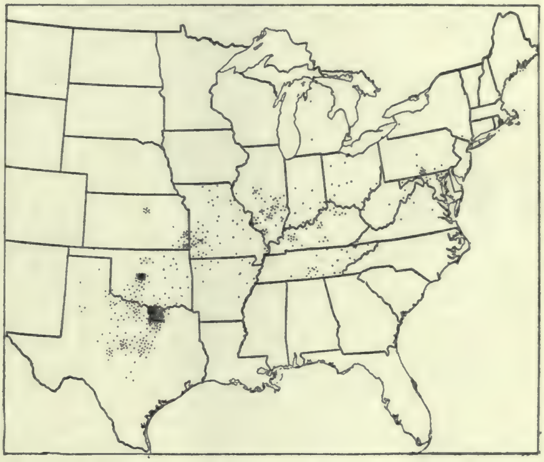


FIGURE 28.—Distribution of Mediterranean wheat in 1934. Estimated area, 519,261 acres.

Mediterranean is grown chiefly in north-central Texas but is widely, though sparingly, grown throughout the eastern United States (fig. 28). For some unknown reason it has rapidly declined in importance in the past few years, its acreage in 1934 being less than 20 percent of what it was 5 years earlier. It is among the highest-yielding varieties in the humid portions of Texas and Oklahoma and also in southeastern Kansas, where it has been grown as Red Sea. Its comparative resistance to leaf rust is a valuable characteristic in this area. This variety has long, tapering, bearded, brown-chaffed heads and very long, soft red kernels (fig. 29, *A*). The plants are tall, mature in midseason, and have purple straw. It is one of the heaviest straw producers of the soft red wheats and is subject to lodging.

The most authentic history of the Mediterranean variety indicates that it was introduced from Genoa, Italy, in 1819, by John Gordon, of Wilmington, Del. During the next 30 or 40 years it spread westward to Missouri, Kansas, Oklahoma, and Texas. It is recommended for Texas and Illinois, where it is known as Red Sea, and for Arkansas.

Mediterranean is also known as Acme, Bluestem, Farmers Trust, Great Western, Key's Prolific, Lancaster Red, Lehigh, Miller, Miller's Pride, Missouri Bluestem, Mortgage Lifter, Redchaff, Red Sea, Red Top, Rocky Mountain, Standby, and Swamp.

DENTON

Denton is a tall, white-strawed selection from Mediterranean made at the Texas Agricultural Substation No. 6, Denton, Tex. It was distributed to Texas farmers in 1926 and has since attained consid-

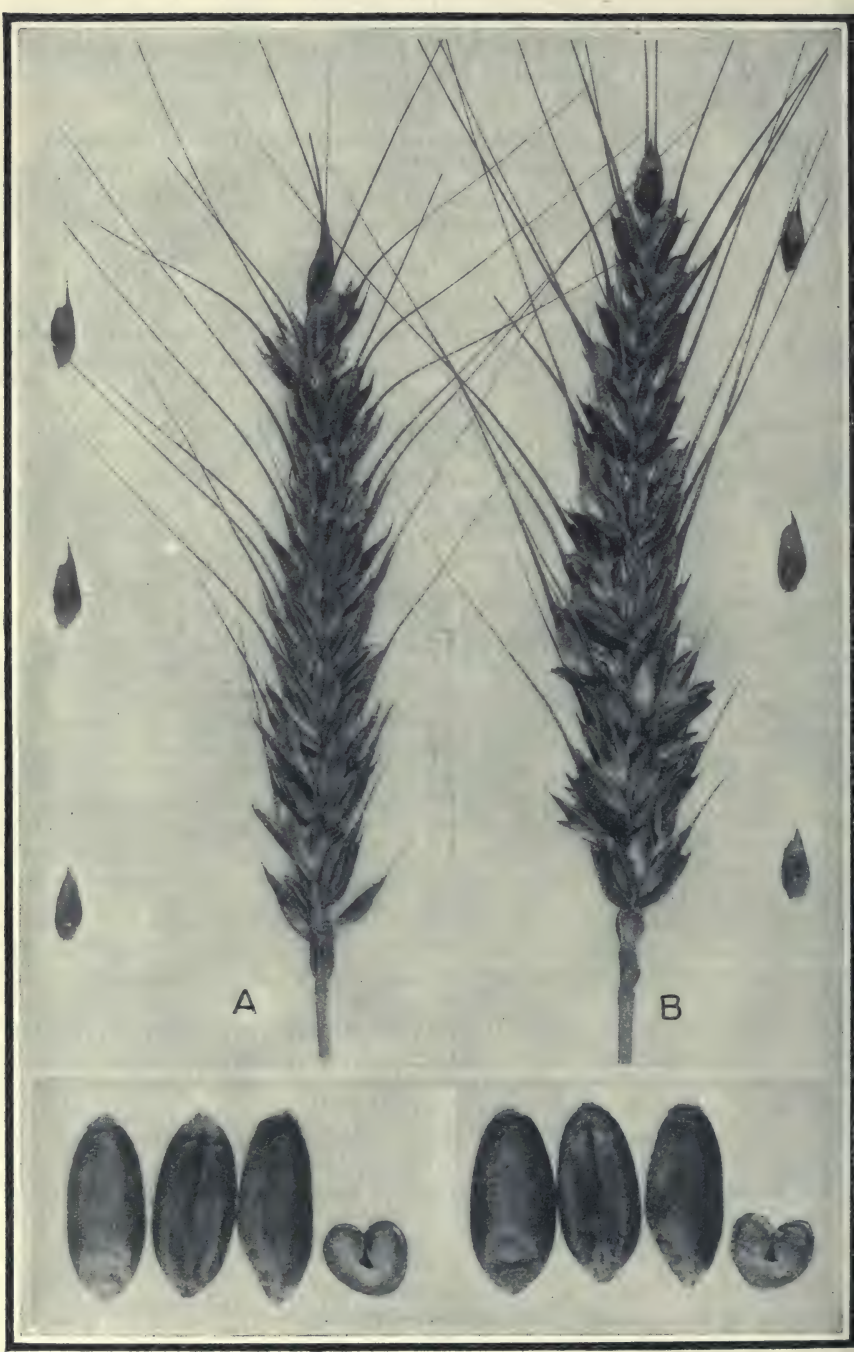


FIGURE 29.—Heads and grain of Mediterranean (*A*) and Red Rock (*B*) wheats

rable prominence in north-central Texas. It matures early, is re- istant to leaf rust, produces high yields, and is less likely to lodge han the parent. Denton is recommended for Texas and Oklahoma.

RED ROCK

Red Rock was originated from a single head found in Goldcoin Plymouth Rock), a white wheat, at the Michigan station in 1907. t is very similar to Mediterranean (fig. 29) and probably was pres- nt in the Goldcoin as a mixture. The heads are somewhat larger nd more open than those of Mediterranean, and the kernels are arder. It is grown principally in Michigan, where it is the leading ariety of soft red wheat (fig. 30). In this State it is prized especially or the quality of the grain for bread. This appears to be largely ecause of its higher protein content as compared with the soft white heat usually grown in that State. Relatively high yields and un- sually stiff straw, which is shorter han that of Mediterranean, have nade it a popular variety on Mich- gan farms. It is relatively nonwinter ardy and should not be grown where inter-killing is likely to be impor- ant. Red Rock is recommended for Iichigan.

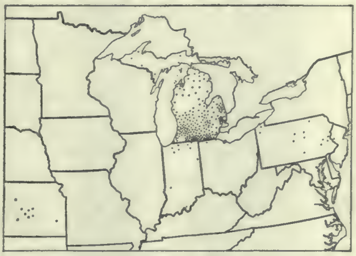


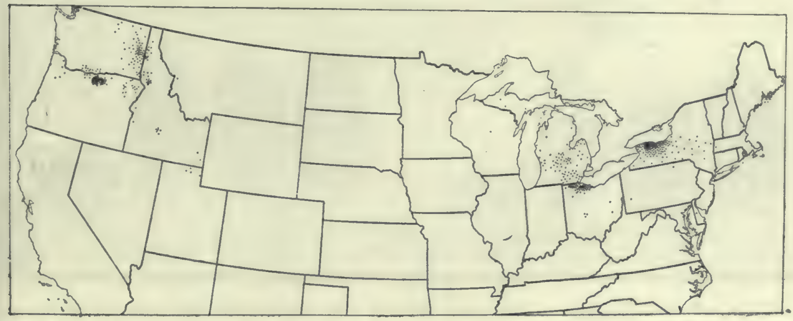
FIGURE 30.—Distribution of Red Rock wheat in 1934. Estimated area, 219,706 acres.

SOFT WHITE WINTER WHEAT

This group includes all varieties of oft winter wheat of commercial im- ortance in the eastern United States aving white grain. The varieties discussed are Goldcoin, Dawson, nd Honor.

GOLDCOIN

Goldcoin (Fortyfold) is one of the leading varieties of white heat in the United States, over 400,000 acres having been grown in 934 (fig. 31). In the eastern United States it is an important va- iety in Michigan, New York, and Ohio. It has excellent straw and oes not lodge easily. Also it produces an excellent pastry flour, nd the grain is highly prized for breakfast cereals prepared from hole wheat. An increased demand for the latter purpose probably one reason for the present acreage.



IGURE 31.—Distribution of Goldcoin wheat in 1934. Estimated area, 437,734 acres.

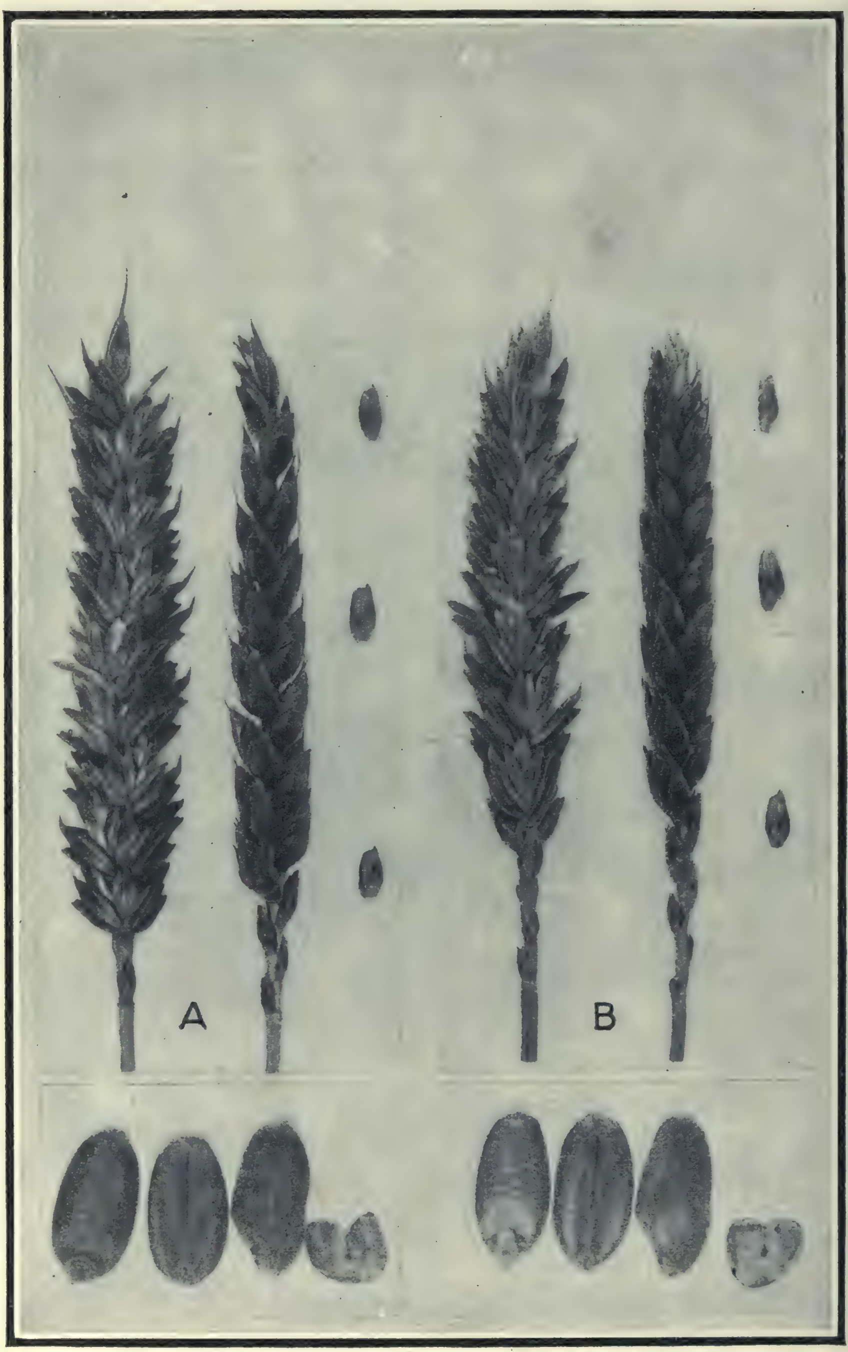


FIGURE 32.—Heads and grain of Dawson (*A*) and Goldcoin (*B*) wheats.

Several conflicting stories respecting the origin of Goldcoin and its various strains have been announced. The New Soules wheat identical with Goldcoin has been known since 1840. Clawson or White Clawson, also identical with Goldcoin, is claimed to have originated in Seneca County, N. Y., in 1865 by selection from a field of Fultz. It is also supposed to be a descendant of a variety grown in the Genesee Valley of New York as early as 1798 and known as Redchaff. The particular strain to which the name Goldcoin was first applied originated from a head found in a field of Diehl-Mediterranean wheat by Ira M. Green, of Avon, N. Y.

Goldcoin wheat has erect, compact heads which have a golden brown chaff. The heads usually are distinctly clubbed at the tip (fig. 32, *B*). The straws or stems are purplish or reddish at maturity. The kernels are midsized, soft, and white. Most of the kernels have a rim or collar around the brush (tuft of hairs at the tip). This feature is often useful in distinguishing the variety from Dawson. The kernels are rather easily shattered from the heads at maturity.

The Goldcoin variety is known by many names, including Abundance, Clawson, Eldorado, Fortyfold, Gold Bullion, Golden Chaff, Gold Medal, Goldmine, Improved No. 6, International No. 6, Junior No. 6, Klondike, New American Banner, New Soules, Niagara No. 6, Oregon Goldmine, Plymouth Rock, Prizetaker, Prizewinner, Rochester No. 6, Soules, Superlative, Twentieth Century, White Century, White Clawson, White Eldorado, White Rock, White Russian, White Soules, White Surprise, and Winter King. In the Western States it is almost universally known as Fortyfold. Some of the names listed above are for supposedly selected strains, but none of them can be distinguished from the parent variety. The variety is recommended for growing in New York, where it is usually known as Junior No. 6, and in Michigan.

DAWSON

Dawson (American Banner) ranks second only to Goldcoin in importance of the white wheats of the eastern United States. It is of commercial importance only in Michigan and New York (fig. 33). The variety differs from Goldcoin chiefly in having white or yellow instead of purple straw and in having an oblong instead of a clubbed head (fig. 32, *A*). Also the kernels do not have the collar or rim around the brush as do those of Goldcoin.

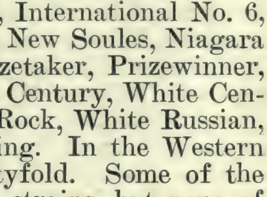


FIGURE 33.—Distribution of Dawson wheat in 1934. Estimated area, 356,108 acres.

With the possible exception of Honor, Dawson is the most winter hardy of the white wheats, though less so than some of the soft red winter wheats. Possibly partly for this reason, it has produced excellent yields in the northeastern United States. In this area it is seldom outyielded by other varieties. Like Goldcoin, it produces a flour that is very satisfactory for pastries or for prepared cereals, although generally inferior for bread.

The Dawson variety was originated from a plant found in a field of Clawson wheat in 1881 by Robert Dawson, of Paris, Ontario, Canada. After it was found to be a high-yielding variety at the Ontario Agricultural Experiment Station, the acreage was rapidly increased. Dawson is recommended in Michigan, where it is known as American Banner, and also in New Jersey.

HONOR

Honor cannot be distinguished from the Dawson variety by any easily observed morphological character. It is slightly hardier, has a stronger straw, and in New York produces better yields than Dawson. It was selected from Dawson at the Cornell (New York) University Agricultural Experiment Station. After trials lasting several years at the station and on farms in New York it was offered for sale in 1920. It is now grown and recommended in that State.

VARIETIES OF HARD RED WINTER WHEAT

As has been pointed out (p. 41), some hard red winter wheat is grown in certain portions of the eastern United States, especially in northern Illinois, northwestern Indiana, southern Wisconsin, and southern Minnesota, and Iowa.

Varieties of this group are grown in the East primarily or exclusively because of their ability to survive cold winters. As compared with those of varieties of soft wheat, yields are high in hot, dry seasons and in those following severe winters in which damage occurs. In wet seasons the hard wheat varieties are likely to lodge and produce low yields. Also the grain that is produced is semihard and usually has a mottled appearance known as yellow berry. Hard red winter wheat is not so satisfactory for bread as the grain of similar varieties from the Great Plains nor as suitable for pastry flour as the true soft wheats. In the extreme eastern United States, where winter injury is mainly due to heaving, the hard red winter wheats often do not survive so well as the soft wheat. For this and other reasons they are not grown in this area.

The leading varieties are Turkey, Kanred, Iobred, Michikof, and Minturki. Turkey is by far the most important. This variety was first introduced into central Kansas by Mennonite colonists who brought seed with them from their former home in Russia. Kanred is a selection from a strain of Turkey made by the Kansas Agricultural Experiment Station. Both varieties have bearded heads, smooth white chaff, and relatively small red grain. The straw is rather weak, and consequently is likely to lodge on very fertile land or in wet seasons.

Ilred, a selection from Turkey, made at the Illinois Agricultural Experiment Station, has been grown to a considerable extent in that State. It differs from Turkey in no important respect but in experimental trials in Illinois has yielded somewhat better.

Iobred, a selection from Banat, made at the Iowa Agricultural Experiment Station, differs from other hard red varieties in having brown chaff and beards and a short, plump kernel very similar to that of Marquis spring wheat. In Iowa it is relatively winter hardy, has strong, stiff straw, and yields relatively well. It is grown extensively in northeastern Kansas and sparingly in Illinois. The grain shatters rather easily; hence the crop should not be permitted to stand long after it is ripe.

Michikof was produced by the Agricultural Experiment Station of Purdue University to meet the demand for a variety that would produce relatively hard, high protein grain for the semihumid Indiana climate. The effort was in part successful, but in the meantime the market situation had changed to such a degree that Michikof is often discriminated against on eastern markets because of its hard grain. The variety is relatively winter hardy and is grown quite extensively in Indiana and in central Illinois largely for this reason (fig. 34). It was produced by crossing Red May (Michigan Amber) and Malakof, the latter a hard winter wheat similar to Turkey. It is the only hard red winter variety of commercial importance in the eastern United States that is awnless.

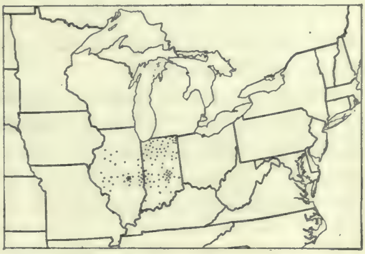


FIGURE 34.—Distribution of Michikof wheat in 1934. Estimated area, 91,923 acres.

Minturki is the most winter hardy of any variety of winter wheat grown on a commercial scale. It is somewhat resistant to stem rust and bunt. It was produced at the Minnesota Agricultural Experiment Station from a cross between Odessa, a very winter hardy soft wheat, and Turkey. Because of its winter hardiness it has given good yields in southern Minnesota and northern Illinois. The grain is somewhat softer than that of Turkey and contains a rather high content of the yellow pigment known as carotene, which imparts a yellow color to the flour. For the latter reason, Minturki flour may require more bleaching than flour from other hard winter wheat.

VARIETIES OF SPRING WHEAT

Spring wheat is not grown extensively in the eastern United States. It is, however, of considerable importance locally in northern Illinois and southern Wisconsin, and a few thousand acres are usually grown in northern New York, Pennsylvania, and Ohio. A million acres of spring wheat was grown in the eastern United States, principally Illinois and Iowa, soon after the World War, but the acreage has since declined to less than 10 percent of this amount. Only four varieties are of commercial importance, viz, Marquis, Java, Progress, and Preston.

Marquis is the leading variety of spring wheat in the eastern United States. It was produced in Canada from a cross between Hard Red Calcutta, an early Indian wheat, and Red Fife. It is noted, especially, for the quality of grain it produces. In the eastern United States it is grown principally in Illinois and Iowa, but it is also found in New York, Maine, and Indiana.

It is a beardless variety with smooth, white chaff, short, plump red grain, and a relatively short, stiff straw that seldom lodges. It is less susceptible to bunt than most other varieties of spring wheat, but very susceptible to stem rust, by which it may be severely injured if the attack gets started early.

The name Java is used for several strains, all of which are bearded and have red grain but vary in color of chaff from white to brown and in grain texture from soft to hard. The most common type has white smooth chaff and soft kernels. It probably is one of the oldest varieties of spring wheat in the United States. A similar or identical variety was grown as Siberian in New York as early as 1837 and in Virginia as early as 1849. Java is now grown principally in Illinois and Iowa, where its early maturity and resistance to scab appear to be the principal reasons for its production. Illinois No. 1, a selection from Java, is grown to some extent in Illinois.

Progress is a selection from Java made at the Marshfield (Wis.) Branch Agricultural Experiment Station. It is more resistant to rust and in Wisconsin is a better yielder than the parent. It matures considerably earlier than Marquis, which also is an advantage in this area. It is perhaps the most resistant to scab of any variety of wheat but produces flour which is poor for bread in comparison with that from most other varieties of spring wheat. It is grown chiefly in southern Wisconsin.

Preston, at one time an important variety of spring wheat, is grown to a limited extent in Illinois and Iowa. It appears to have no outstanding characteristics that commend it above those already described. It is a bearded variety with smooth, white chaff and rather slender, red grain similar to that of hard red winter.

NEW VARIETIES OF SOFT WINTER WHEAT

In recent years a number of new varieties of soft winter wheat have been released for distribution to farmers. Not a great deal is known regarding their adaptation or their value outside of the States where they were originated.

Clarkan probably is the result of a cross between Blackhull and Harvest Queen. It was selected by Earl G. Clark, a farmer living near Sedgwick, Kans. It was first distributed to Kansas farmers in 1934 and is now recommended by the Kansas Agricultural Experiment Station for eastern Kansas. The variety has large, soft, red grain and a very stiff straw, and in Kansas has given very satisfactory yields.

Leapland is a selection from Leap made by the Maryland Agricultural Experiment Station. It is very similar in appearance to Leap but in Maryland has given higher yields.

The designation V. P. I. 112 has been given to a selection similar to Poole made by the Virginia Agricultural Experiment Station. It is recommended for the higher upland soils of that State.

Valprize is the result of a cross between Valley and Grandprize made by the New York (Cornell) Agricultural Experiment Station and recently distributed to farmers of that State. It has very soft, light-red kernels which produce a flour of excellent pastry quality.

Canawa was selected by the West Virginia Agricultural Experiment Station from a badly mixed variety known as Canadian Hybrid. The characteristics of the new variety suggest that its immediate parent may have been a natural cross between Red May and Jones Fife. It has beardless nodding heads, smooth white glumes, or chaff, and semihard, short red kernels. In cooperative tests with farmers in West Virginia it produced better yields than other varieties with which it was compared.

Thorne, a beardless, brown-chaff variety with soft red grain, was developed at the Ohio Agricultural Experiment Station from a cross between Portage and Fulcaster and distributed in the fall of 1937. It is resistant to the races of loose smut present in Ohio and to mosaic. It is more resistant to lodging and has given higher yields than Trumbull in Ohio.

Wabash, a beardless, white-chaff variety, was selected from a plot of Fultz at the Purdue University Agricultural Experiment Station, because of its high degree of resistance to leaf rust. It is quite different from the parent variety, however, and is undoubtedly the result of a natural hybrid. It has been a high-yielding variety in Indiana and Illinois and was approved for distribution in those States in the fall of 1938. It is resistant to leaf rust and mosaic but susceptible to flag smut.

Purdue No. 1, a beardless variety with red chaff, was developed at the Purdue University Agricultural Experiment Station from a cross between Michigan Amber and Rudy. It was first grown on farms in 1934. Purdue No. 1 is somewhat resistant to leaf rust but susceptible to mosaic and to loose and flag smuts. It has given high yields in Indiana.

Illinois No. 2, a bearded variety with brown chaff and soft short red grain, is a selection from Indiana Swamp (Valley) made at the Illinois Agricultural Experiment Station in 1915. It was distributed in the fall of 1932. It is winter hardy and somewhat resistant to leaf and stem rust. It is, however, susceptible to the mosaic disease and to flag smut.

Brill is the best of 6,000 head selections from Turkey made at the Illinois Agricultural Experiment Station in 1922. It was distributed in Illinois in the fall of 1936. Brill is bearded and has light brown chaff; its hard red grain is resistant to yellowberry. This variety is winter hardy and somewhat resistant to flag smut, leaf rust, and scab. It is, however, susceptible to mosaic.

Early Premium was selected from a farmer's field of "May" wheat (probably Rice or Zimmerman) by the Missouri Agricultural Experiment Station and was distributed to farmers in the fall of 1937. It is a very early variety with soft red grain, a beardless head, and white chaff. Because of its early maturity, it is recommended by the Missouri station for growing especially when lespedeza is sown in the wheat crop or when wheat is to be followed by a summer crop such as soybeans. Its early maturity also enables it to escape stem rust in some years.

Yorkwin is a selection from a cross between Dietz (Fulcaster) and Goldcoin made in 1919 at the Cornell University Agricultural Experiment Station. It is a beardless, white-chaff variety with soft white kernels and is a high-yielding variety in New York State. It was distributed to farmers in 1935.

GROWING WINTER WHEAT

Many factors are involved in successfully growing a crop of wheat. Only the more important ones are considered here.

ROTATIONS

It is not advisable or profitable to grow wheat continuously on the same land in the eastern United States. Wheat fits well in the crop rotations ordinarily used in this region.

WHEAT ROTATIONS FOR THE CORN BELT

A good wheat rotation contains at least one legume and one or more cultivated or row crops. In the Corn Belt these requirements are easily met with corn and clover. Seeding with wheat serves as a convenient and inexpensive means of obtaining a stand of clover, as the preparation of the ground for wheat suffices also for clover. As a nurse crop, wheat shades the ground less and is harvested earlier than oats and usually is more profitable than rye. Inasmuch as cattle are commonly raised on most farms, the growing of wheat is an advantage, since it is of value for pasture, feed, and bedding.

The fact that wheat is well suited as a nurse crop for clover or grasses, whether alone or in combination, means that it should occupy a place in the rotation preceding them. Where corn can be grown successfully, it makes better use of the improved productivity of the land brought about by growing clover and grass than most any other crop. Corn, therefore, is usually grown following these crops.

Oats, sometimes, can be sown conveniently after corn and harvested early enough to provide plenty of time to prepare the land for a following crop of wheat. Thus a natural and efficient rotation for much of the eastern United States is wheat 1 year, clover and timothy 1 or 2 years, corn 1 year, and oats 1 year. Ordinarily, the clover and timothy or as much of the clover as is left after the first winter, is grown 2 years. On very rich soil corn may be grown 2 years successively, thus increasing the length of the rotation and the acreage of the corn crop.

Cowpeas or soybeans may be substituted very profitably for oats in many localities where oats do not pay, or wheat may be grown 2 years in succession. In tobacco-growing localities, tobacco may be grown in place of the oats. Barley may occasionally be substituted for oats, but spring barley is not a very satisfactory crop on poor soil or in localities where scab or chinch bugs are likely to be prevalent, as in Illinois, Iowa, and Missouri.

In recent years it has been found that wheat often is more profitable after soybeans or cowpeas than after corn; hence, when these crops are grown, the rotation may well be corn, cowpeas or soybeans, wheat, and clover, each 1 year. Such a rotation is especially satisfactory if the cowpeas or soybeans are to be cut for hay. In any case all that is necessary to prepare the land for wheat is a thorough disking, or even this may be dispensed with if the ground is loose and mellow as is frequently the case.

Some good rotations or cropping systems for the central and northern parts of the region are as follows:

Rotation No. 1: Corn; wheat; clover.

Rotation No. 2: Corn; wheat (clover and grass seeded with wheat); clover and grass 2 years.

Rotation No. 3: Corn 2 years; wheat; red clover or sweetclover.

Rotation No. 4: Corn; oats, soybeans, or cowpeas; wheat; clover.

Rotation No. 5: Wheat; clover and timothy 1 or 2 years; corn; oats.

Lespedeza is becoming a popular crop in those areas where it can be grown, especially where an important objective is to improve the soil or prevent damage from erosion. The lespedeza seed is sown (usually broadcast) early in the spring on the fall-sown wheat, and, after wheat harvest, may be pastured or permitted to make a crop of hay or seed. If wheat is to be seeded again, the land is prepared by disking. As the lespedeza reseeds itself, the wheat-lespedeza rotation may be grown continuously. To be fully successful an early variety of wheat must be used.

Some of the more common rotations including wheat and lespedeza are:

Rotation No. 1: Corn; wheat, lespedeza for pasture, hay, or seed; wheat.

Rotation No. 2: Corn; wheat, lespedeza for pasture, hay, or seed; lespedeza.

Rotation No. 3: Corn; wheat, lespedeza for pasture, hay, or seed.

Rotation No. 4: Corn; soybeans; wheat, lespedeza for pasture, hay, or seed.

Rotation No. 5: Wheat; lespedeza for pasture, hay, or seed; lespedeza for pasture, hay, or seed.

Where wheat immediately follows corn, as in rotations 1, 2, and 3, the corn is cut and shocked or put into the silo, thus permitting the regular seeding operation, or the wheat is seeded between the standing rows of corn with a narrow one-horse drill. In many sections wheat also is sown between the rows of corn shocks.

WHEAT ROTATIONS FOR THE COTTON BELT

In the southern part of the region, somewhat different rotations are preferable because of the longer growing season, the different type of soil, and the fact that cotton is the leading crop. Because of the late maturity of cotton, wheat cannot be grown immediately after this crop. Usually, therefore, if cotton is included in the rotation, it is followed by corn. The following rotations including wheat have been found satisfactory:

Rotation No. 1: Wheat, followed by cowpeas or soybeans for hay or seed; cotton, well-fertilized, with vetch or Austrian winter peas planted between the rows for green manure; corn, stalks cut and removed from the field.

Rotation No. 2: Wheat, followed by cowpeas or Otootan soybeans for hay or seed; corn and velvetbeans; Laredo soybeans planted early and cut for hay.

Rotation No. 3: Corn, crimson clover at last cultivation; soybeans or cowpeas; wheat (clover and grass seeded with wheat in the spring); clover and grass 2 years.

FERTILIZERS AND MANURE

Commercial fertilizers and manure may be used to good advantage in growing the wheat crop. The best fertilizer or fertilizer combination to use on wheat or in a rotation containing it depends largely on the productivity of the soil. This productivity is related to the nature of the soil and to its previous treatment. Usually the State agricultural experiment stations have fertilizer experiments on the different soil types and are prepared to make specific recommendations. A limited quantity of commercial fertilizer applied to the wheat crop usually pays on the soils of the eastern United States.

Soils of the eastern United States, except the dark-colored soils of the prairies and of low-lying, imperfectly drained areas, commonly lack nitrogen. When the wheat plants have light-green foliage it is usually an indication of a shortage of available nitrogen. The nitrogen deficiency usually can be most economically corrected by plowing under crops of legumes, such as red clover, sweetclover, cowpeas, or soybeans. However, it is sometimes desirable to supplement this supply with commercial nitrogen or even to depend on the latter exclusively. Nitrate of soda or sulphate of ammonia are commonly used for this purpose. A common practice is to apply them broadcast on the surface of the ground early in the spring at the rate of about 100 pounds per acre.

Phosphorus is more generally used for wheat than any other commercial fertilizer in the eastern United States. It is largely supplied in the form of superphosphate or rock phosphate. The application is usually made either just before or at the time of seeding. From 200 to 300 pounds of superphosphate per acre are commonly used.

Potash should be applied to soils of low fertility, especially sandy soils on the Coastal Plain. On clay or loam soils, the application of potash usually does not pay.

A complete commercial fertilizer is one in which all three of the most frequently deficient plant foods, nitrogen, phosphorus, and potash, are present. Mixed fertilizers are usually satisfactory, but definite recommendations as to formulae and amounts should be obtained from the State experiment stations. One of the fertilizers commonly used for wheat is 200 to 300 pounds of a 2–12–6—i. e., 2 percent of nitrogen, 12 percent of phosphorus, and 6 percent of potash. A fertilizer of approximately this ratio is often used on sandy soils. For loam and clay soils the nitrogen may be omitted and the phosphorus increased, giving a 0–14–6 content. The nitrogen should be omitted if lodging is at all frequent. Also, if manure is used in the rotation, the nitrogen may be left out unless the soil is in a very poor state of productivity.

When the soil is acid, an application of lime—either the ground limestone or air-slaked lime—is beneficial. Wheat itself is not injured by a slightly acid soil, but most legumes grown in the rotation will be decidedly benefited by the use of lime.

Manure is a valuable fertilizer for wheat, but usually it is best applied to the corn crop when the latter is in the rotation. On both light sandy soils and heavy clay soils, well-rotted manure plowed under supplies the humus necessary to improve the physical condition of the soil and also adds valuable nutrients, particularly nitrogen and potash. The manure may be applied before seeding or as a top dressing to the wheat in late fall or early winter. Four or more tons to the acre are recommended, the heavier rates of application on the lighter soils.

PREPARING THE LAND

The time and method of preparing the land for wheat depends principally on the crop which precedes it. As a rule, it is desirable to have the land prepared considerably in advance of seeding to permit settling and the accumulation of moisture and available plant food, especially nitrates. When the land is to be plowed, as after a small-grain crop, at least a month should intervene between plowing and seeding. The land should be plowed, preferably, immediately after harvest, since otherwise weeds and volunteer grain will grow and rob the soil of moisture and nitrates that should be conserved for the following crop. The soil can be most easily and much better prepared when it is in proper friable condition. This often occurs soon after harvest. After the ground dries out it is likely to turn up cloddy and lumpy and will be difficult to work into a good seedbed. If for any reason plowing must be delayed, disking the ground immediately after harvest is beneficial. After plowing, the ground should be worked with disk and harrow, as necessary, to keep weeds and volunteer grain under control and get it in condition for seeding. Figure 35 illustrates a method of working the ground into condition for wheat.

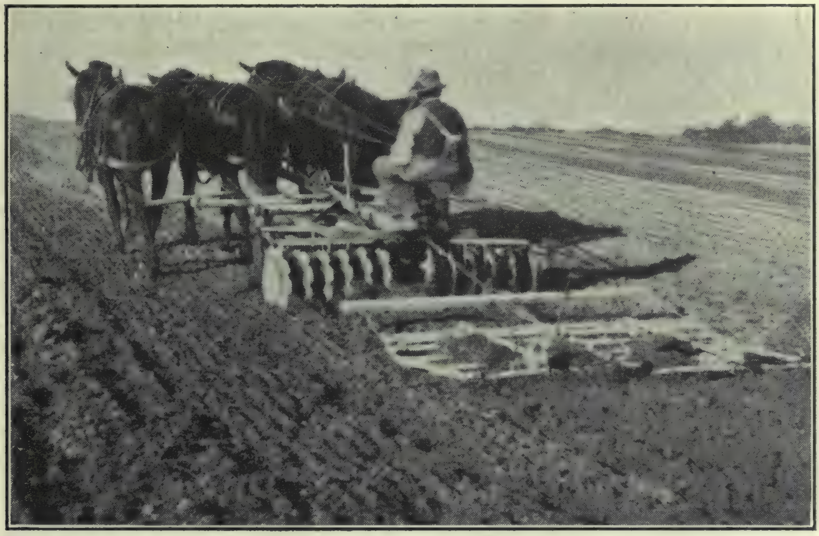


FIGURE 35.—Disking and harrowing the ground for wheat in one operation.

The depth of plowing should be governed to a considerable extent by the quantity of stubble, weeds, and cover crop to be turned under, and should be sufficient to do this thoroughly. Also, the plow may be run somewhat deeper if plowing is done early rather than late. A common practice is to plow 6 to 7 inches deep in July and early August, gradually decreasing the depth to 4 to 5 inches in late August and September. Ordinarily there is no advantage in plowing deeper than is here indicated.

Much of the acreage of wheat in the eastern United States follows corn or soybeans in the rotation. Usually, in such cases the time of harvesting and the condition of the land after the crop is removed determine the preparation of the ground for wheat. Corn in this area is often cut and shocked in the field to be husked later. Under such conditions preparing the ground with a disk or a spring-tooth harrow is a common practice. Soybeans often leave the ground free from weeds, friable, and in good condition for seeding with no preparation whatever or only by disking and harrowing.

SEED

Wheat, unlike corn, is normally self-pollinated, and for this reason an adapted variety will change very slowly, if at all, because of the locality in which it is grown. However, in such old varieties as Fultz and Fulcaster there are strains differing from each other, especially in productivity. Accordingly, it is usually preferable to obtain locally seed of the variety one wishes to grow. Once a suitable variety has been obtained, maintaining good seed requires roguing (removing other grain mixtures) of the plants in that part of the field desired to be harvested for seed. It usually is best to thresh the seed bundles after threshing the main crop to lessen the chance for mixing in the threshing machine.

Weed seeds, smut balls, and broken and small kernels should be removed with the fanning mill. If the wheat has a heavy infestation of bunt (stinking smut), is moldy, or shows signs of having sprouted, it should not be used for seed. Seed not too heavily infested with bunt may be used if treated as directed on page 43.

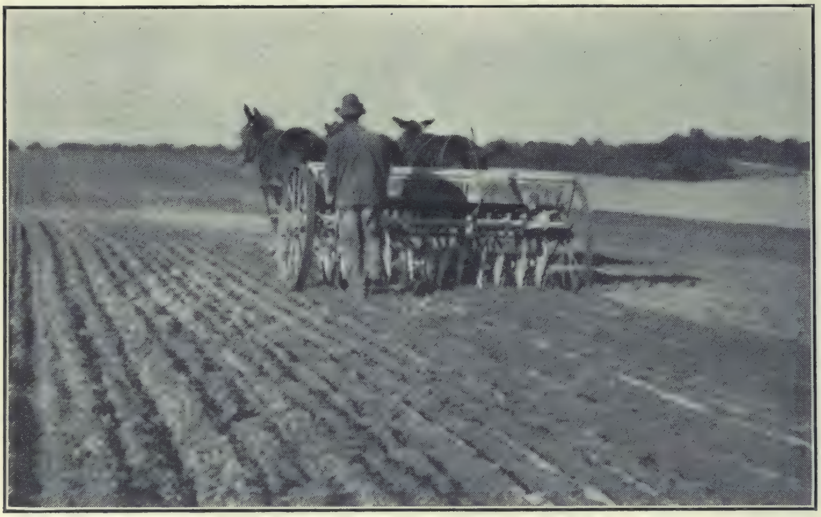


Figure 36.—A disk drill in operation.

Sound wheat that has been stored in a dry bin ordinarily germinates satisfactorily. However, if it has been wet or there is any other reason to suspect that its vitality has been injured, it should not be used, unless a germination test is made. It should not be used if it germinates less than 90 percent. Wheat, 1, 2, or even 3 years old, may be used for seed if it germinates satisfactorily. Seed older than this is likely to be weak.

SEEDING

In the early history of this country wheat was sown broadcast for want of satisfactory machinery, but at present winter wheat is almost universally sown with a drill (fig. 36). Drilling saves seed, insures better germination, reduces winter injury, and almost always produces better yields. Drills are of three general types: Hoe, shoe, and single- and double-disk drills. Single-disk drills are most commonly used. Hoe drills are satisfactory only on clean land and have some advantages on stony land. Drills with rows 6 to 8 inches apart are generally the most satisfactory.

Winter wheat in the eastern United States is usually sown at the rate of from 5 to 8 pecks per acre. Usually 6 pecks or more per acre will produce larger yields than a lesser quantity. The Ohio Agricultural Experiment Station has conducted extensive tests with various rates of seeding with a number of varieties for a period of 17 years. On an average, 8 pecks per acre gave the most profitable yields. Seeding at 6 and 7 pecks per acre was only slightly inferior. Heavier seeding than usual is ordinarily advisable if seeding is delayed beyond the normal date, since there is less opportunity for the plants to stool.

Certain varieties have been advertised as having the ability to stool more than others and requiring less seed per acre. This claim, in general, is unfounded. Varieties do differ in their ability to stool, but all recommended varieties, if seeded at the proper time and under favorable conditions, will tiller sufficiently to enable the plants to fully occupy the land.

There is no advantage in seeding wheat deeper than necessary to insure sufficient moisture for good germination. In light soils the seed may be safely sown deeper than in heavy soils. Covering the seed from 1 to 1½ inches is usually sufficient.

Wheat should be sown early enough to become well established before winter, but not so early that it makes a rank growth or starts to shoot before winter, nor early enough to become infested with hessian fly if this insect is prevalent. Usually this means early enough to permit tillering so that the wheat will cover the ground reasonably well. Unless wheat is grown for pasture, there is seldom any advantage from very early seeding, and there is considerable danger from lodging, winter-killing, and the hessian fly.

When the hessian fly is prevalent, it is advisable to delay fall seeding until the safe date, which is the earliest date in the fall at which wheat can be seeded and still, with average conditions, escape damage from the hessian fly. These dates have been established experimentally and, of course, vary for different parts of the country. Safe average dates for seeding are indicated in Farmers' Bulletin 1627, but as the actual dates may vary from year to year, wheat growers are advised to consult their State agricultural experiment stations or county agents regarding the best seeding date for specific counties or areas for any given year.

On well-prepared land in the average season, the safe date is early enough to permit a satisfactory growth of wheat before winter and maximum yields. On the other hand, it is as late as can safely be recommended. For this reason and because of possible delays due to bad weather, it is usually advisable, when the hessian fly is not present, to start seeding approximately a week or 10 days earlier than the recommended safe dates.

PASTURING

Wheat is a highly nutritive pasture crop, and when the pasturing is done with judgment no injury to the grain crop results. It should be remembered, however, that the plants should be well established before pasturing begins; otherwise, the plants may be uprooted by animals while grazing. This date will depend upon the growing season. Livestock should be kept off during wet weather. If grass or clover has been sown with the wheat, injury is likely to be especially severe, if the wheat is pastured when the land is muddy. Spring pasturing may be practiced under favorable conditions, but a loss in grain yield should be expected. The loss is likely to be especially heavy if pasturing is permitted after the plants begin to shoot, which usually takes place a few weeks after growth starts. Excessive pasturing at any time of the year is likely to reduce yields.

MULCHING AND CULTIVATING

An application of straw, not exceeding 2 tons per acre, applied as a top dressing in the late fall or early winter is sometimes recommended as a means of decreasing winter injury. Without doubt, the straw is beneficial in this respect, but in nearly all cases where it has been tried it reduces the yields in seasons when no winter injury occurs. Also a mulch of wheat straw from the preceding crop may be an important source of insect pests such as the hessian fly, strawworm, and jointworm. Mulched wheat is often yellow in the spring, indicating that the straw reduces the supply of available nitrates in the soil. The Ohio Agricultural Experiment Station recommends 1 to 2 tons of straw per acre on unmanured light-colored soils low in productivity where winter-killing is likely to occur. It should be spread uniformly in late November or December.

Rolling wheat in the spring with a corrugated roller is sometimes beneficial as, for example, when the soil is badly cracked or the wheat plants have been heaved by alternate freezing and thawing. Except in such cases neither rolling nor harrowing is likely to pay. To be beneficial, rolling must be done as soon as growth starts in the spring but should not be practiced when the top soil is wet.

HARVESTING

Wheat in the eastern United States is largely harvested with the grain binder. During the past 10 years the use of the combine harvester, commonly called the combine, has come into some favor. With this machine the grain is cut and threshed at one operation.

The principal advantages are the opportunity to harvest and thresh promptly while the weather is favorable, and to save labor. Objections are that the grain cannot be harvested until it is fully ripe or overripe, thus increasing the risk from storm damage and the danger of spoilage in the bin, which almost inevitably results when damp or slightly immature grain is put into a tight bin in large quantities. Also in the eastern United States the acreage of wheat on individual farms is not usually sufficient to warrant so heavy an investment in harvesting machinery. Another serious objection on many farms is that, with the combine, the straw is scattered over the land instead of being preserved in a stack or the mow for feed and bedding. In the eastern United States the objections usually outweigh the advantages, except on large grain farms.

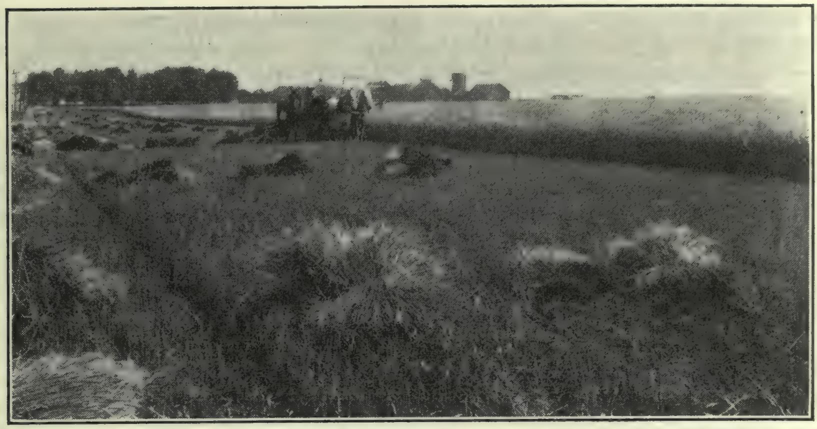


FIGURE 37.—Harvesting a field of soft winter wheat in La Salle County, Ill.

Where the wheat is to be harvested with the binder, the crop is ready when the straw is well-colored, either purple or yellow, and the grain is in what is known as the hard-dough stage. A harvesting scene is shown in figure 37.

SHOCKING

Immediately after being cut with a binder, the wheat should be shocked (fig. 38). A well-built shock saves considerable grain loss in wet weather. The shock should be large enough to avoid being blown over by winds but not large enough to cause molding of the heads. Usually 12 or more bundles form a shock. The first two bundles should be set upright firmly on the ground with the heads well together. The remaining bundles are set firmly in the stubble around these two. The shock is completed by capping it with two bundles the stalks of which have been bent down at the band.

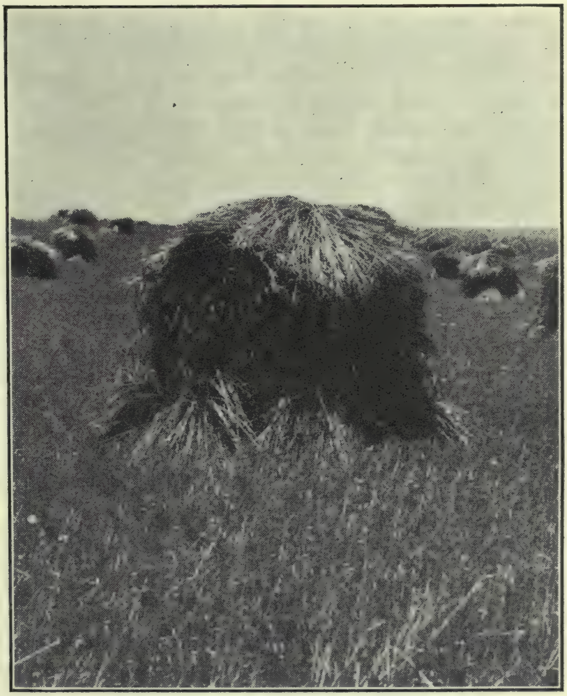


FIGURE 38.—A shock of wheat.

Storing wheat in the barn or stacking it in the barnyard is occasionally practiced. The advantages in either case are that the grain is protected from the weather and that threshing may be done at a more convenient time. The principal disadvantage is the additional labor expense because of the extra handling.

THRESHING

The majority of farms in the eastern United States depend on custom threshing. This means that the interval between cutting and threshing may be several weeks. Well-shocked wheat will, however, be little injured by ordinary weather, and it is the more common practice to thresh direct from the shock rather than to stack the grain or store it in barns. The latter is still done, however.

In sections where the Angoumois grain moth is prevalent, it is especially desirable to thresh as soon as the grain is dry enough to store, or severe losses in grain may result. In these sections the use of storage bins, thorough cleaning of these bins before storage of the new crop, and fumigation of the grain immediately after storage are advisable.

Wheat should not be threshed when the straw is tough or the grain wet. It is much easier to dry the grain before threshing rather than after.

The straw is commonly stacked in the open and used for roughage and bedding for stock during the winter. Ultimately it should find its way back to the soil. Close to cities or poultry sections, wheat straw can often be baled and sold at a profit.

GROWING SPRING WHEAT

As indicated on page 29, a small acreage of spring wheat is grown in Iowa, northern Illinois, and southeastern Wisconsin; only a little is grown in New York, Pennsylvania, and Ohio. Spring wheat receives attention especially when, for any reason, winter wheat cannot be seeded or is killed during the winter. Also, under reasonably favorable conditions, spring wheat may prove more profitable than oats and is often considered a very satisfactory nurse crop for grass and small legumes.

Usually spring wheat occupies the same place in the rotation as oats—that is, after corn. Both corn and wheat harbor the fungus (*Gibberella saubinetii* (Mont.) Sacc.) which causes scab, and since the fungus spores live through the winter on old cornstalks and are disseminated by the wind in the spring, there is serious danger of scab infection in spring wheat if the cornstalks are not removed or plowed under. Since early seeding is desirable, it is a good plan to plow in the fall. However, a thorough disking and harrowing in the spring will prove reasonably satisfactory if fall plowing is not done. It is especially important that spring wheat be seeded as early in the spring as the ground can be prepared. In a 5-year test at the Illinois Agricultural Experiment Station, in which spring wheat was sown at 10-day intervals beginning as early in the spring as possible, there was a progressive decrease in yield in the later seedings. For the earliest seedings, the average date of which was March 6, the average yield was 25.7 bushels, as compared with only 16.2 bushels for seeding at what is considered the normal date (April 5) for seeding spring small grains.

Spring wheat may be seeded with a drill or sown broadcast, as with an endgate seeder. The former produces larger yields and is to be preferred, other things being equal. Sometimes, however, seeding can be done earlier if the broadcast method is used, and frequently the gain from the early seeding will more than offset the loss as compared with drilling. The broadcast method also is more rapid and less expensive, except that more seed may be required. Both methods are used.

The rate of seeding is usually higher for spring than for winter wheat. The Illinois station recommends approximately 2 bushels per acre.

DISEASES OF WHEAT

Rusts, smuts, and scab are the most common and most destructive diseases of wheat in the eastern United States. Others, such as take-all, septoria, mosaic, and nematode disease, may in some years cause important local losses. With the exception of the rusts and septoria, these can be controlled, at least to a reasonable degree.

In addition to these there are a number of diseases, mostly of lesser importance, for which no satisfactory control measures are known. Some of these are helminthosporium leaf spot and foot rot, anthracnose, powdery mildew, ergot, black chaff, and basal glume rot.

RUSTS

Two important diseases of wheat in the eastern United States are stem rust and leaf rust; the first is so called because it attacks the stems of the plants principally and the second because it attacks the leaves principally. Both are due to small parasitic fungi the spores of which are carried by the wind to the wheat plant, there to develop at the expense of the wheat.

It was not until about 200 years ago that anything of importance was known regarding the nature or cause of rust. The Romans attributed the periodic ravages to a special rust god, Robigus, who resorted to this means of wreaking his vengeance on a wicked people. According to another belief, the rust was due solely to the weather. It is now known that there must be favorable weather for the development of the fungus and also that spores must be present.

Of the two kinds of rust, stem rust is by far the most destructive, and the effects are more conspicuous, since it causes badly shriveled kernels and in a very few days may reduce the yield to a fraction of what would otherwise be secured. Fortunately, it does not occur in damaging amounts generally in the eastern United States, although it has been known to cause severe losses in some years.

Leaf rust is present nearly every year and is widespread. It reduces the number and size of kernels and the yield and the protein content of the grain. The effect is not conspicuous, however, and usually passes unnoticed. In the aggregate the losses no doubt are heavy.

Neither leaf rust nor stem rust can be prevented by seed treatment, nor indeed by any kind of treatment that is practical after the plants once become infected. Destruction of certain kinds of barberry plants on which the stem rust fungus lives during a part of the year, is known to be beneficial in reducing losses from this disease. Aside from this, the only practical means of avoiding losses is to grow resistant varieties or those that are able to escape damage because of their early maturity.

There are at present no varieties of wheat well adapted to the eastern United States that are highly resistant to stem rust and none that are highly resistant to all races of leaf rust. Hence the farmer can scarcely expect to entirely avoid losses from these diseases. The varieties recommended elsewhere in this publication are either moderately resistant to stem rust and leaf rust, or mature early and thereby escape severe damage, or have other desirable characteristics of sufficient importance to overbalance their susceptibility. The use of these varieties, therefore, is recommended until such time as resistant varieties, satisfactory in other respects, are available.

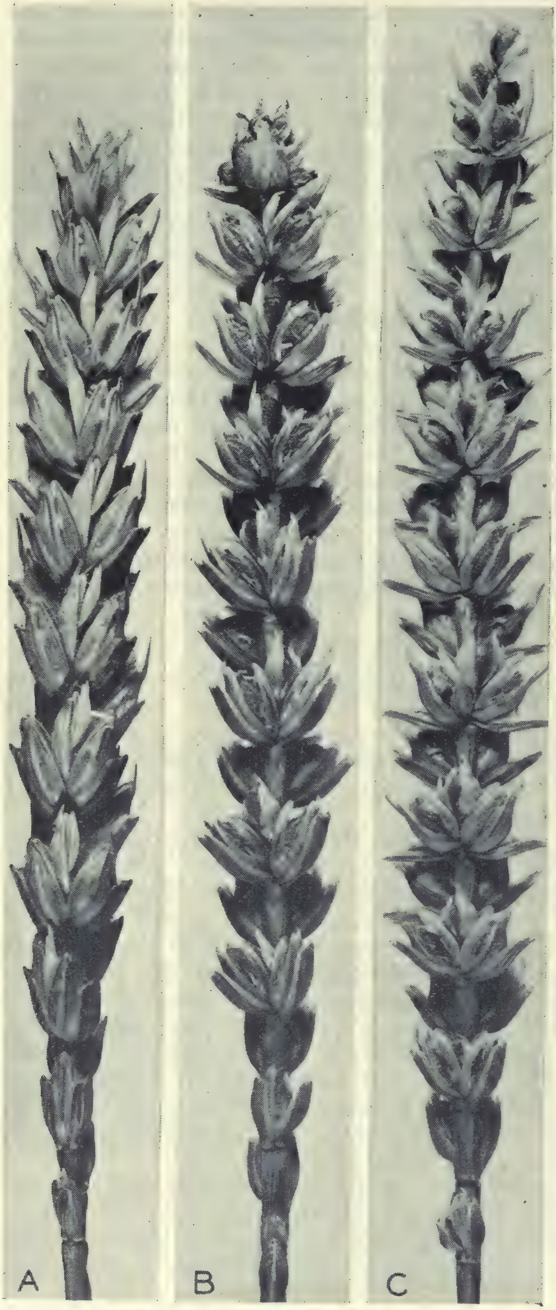


FIGURE 39.—Harvest Queen wheat: *A*, Sound head; *B* and *C*, bunted heads.

SMUTS

There are two important kinds of smut of wheat in the eastern United States: Stinking smut, or bunt, and loose smut. Flag smut also occurs in limited areas. Loose smut can be distinguished by the fact that black spores replace both the grain and the chaff and are blown away by the wind before harvest, leaving the bare central stem (rachis) of the head. Stinking smut, or bunt, on the other hand, replaces the grain only with balls of spores, leaving the outer coat of the kernel and also the chaff intact. As its name implies, it can be distinguished also by its characteristic fetid odor. The stinking smut, or bunt, is the more important of the two. It not only reduces the yield but also lowers the quality and the market value of the grain. Flag smut attacks the leaves only and can be distinguished from the others by that fact. It may seriously reduce the yield under conditions favorable for the smut.

BUNT, OR STINKING SMUT

Bunt, or stinking smut, is carried over from one crop to the next as black spores on the seed or as smut balls mixed with the seed. When bunt-infested seed is sown under favorable conditions, such as in moist, cool soil, the smut spores germinate, and the fungi penetrate into and infect the young seedlings. As the infected plants grow, the smut fungi grow within them and produce what are commonly called smut balls instead of kernels in the heads. When the wheat is ripe, the presence of these smut balls is made evident by the odor and the appearance of the smutted heads (fig. 39). The smut balls are grayish brown or almost black and are about the size and shape of the wheat kernels (fig. 40, p. 44). When crushed in the fingers, the smut balls are found to be filled with foul-smelling smut dust—the spores of the causal fungus. Most wheat growers are familiar with smut balls as they are threshed with wheat and with the foul-smelling odor as it comes from the machine. Badly smutted wheat must be washed or "scoured" before milling to remove both the smut spores and the odor. Because of this, smutty wheat is discounted on the market.

There are no varieties of wheat commonly grown in the eastern United States that are resistant to all strains of smuts, although some varieties are more resistant than others. Therefore, seed treatment, for the present, must be relied upon for control.

Very badly smutted wheat should not be used for seed. Moderately smutted seed can be safely used if thoroughly cleaned in a good fanning mill and then well dusted with copper carbonate, New Improved Ceresan, or basic copper sulphate before being sown, as described on page 45. Formaldehyde also may be used, but it is likely to injure the germination of the seed.

SEED TREATMENTS FOR BUNT

The most widely used seed treatments for stinking smut, or bunt, in winter wheat are the copper carbonate dust treatment and the ethyl mercury phosphate dust treatment (New Improved Ceresan). Either of these is satisfactory in the eastern United States, where soil infestation does not occur, provided that the seed wheat has been thoroughly cleaned before treatment and was not too heavily smutted to begin with. Wheat that is black with smut spores is unsuitable for seed. All the smut balls should be removed before the seed is treated.

Experiments have shown that basic copper sulphate, a promising seed-treatment compound lately placed on the market, is equal to copper carbonate for controlling stinking smut.

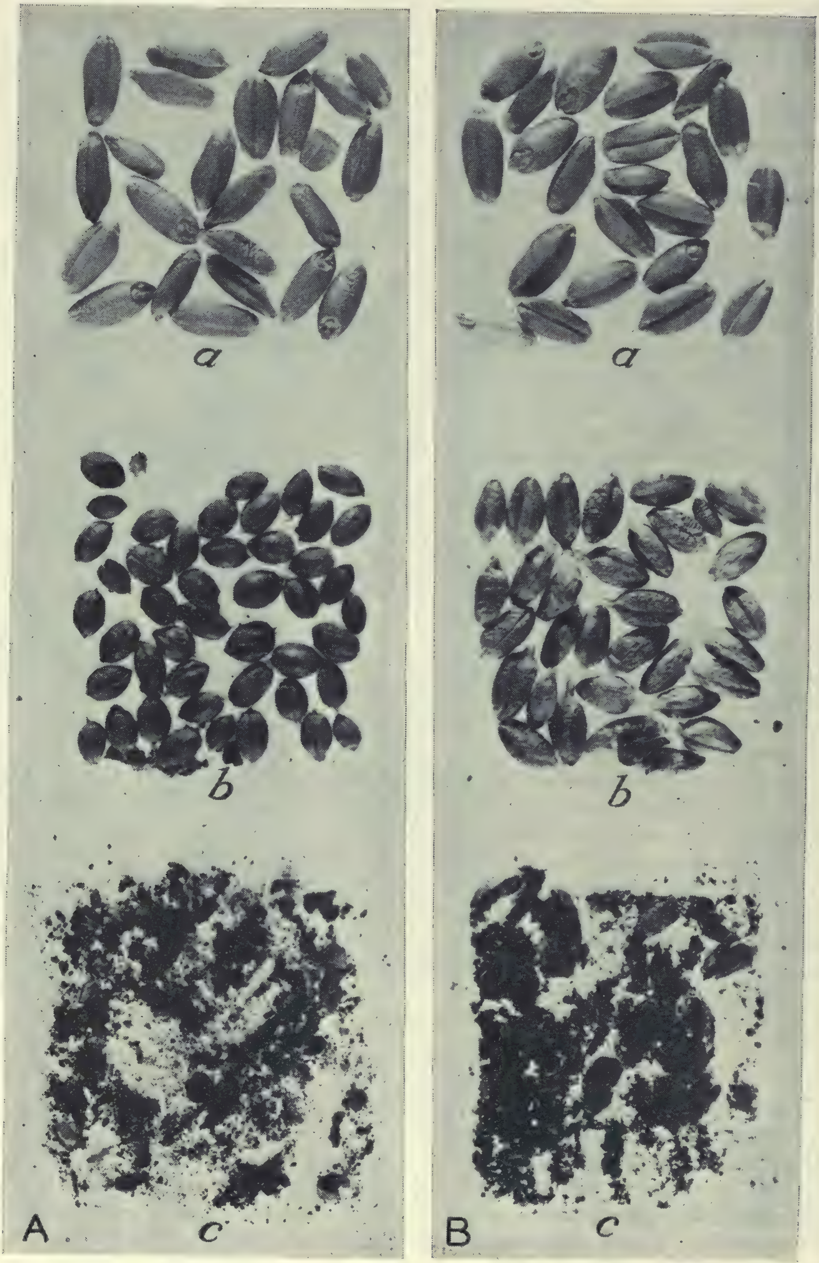


FIGURE 40.—*A*, Stinking smut on Kanred wheat: *a*, Wheat grains; *b*, smut balls; *c*, smut spores. *B*, Stinking smut on Harvest Queen wheat: *a*, Wheat grains; *b*, smut balls; *c*, smut spores.

These seed treatment compounds may be purchased at drug stores, seed houses, or other places where seed and similar products are for sale.

COPPER CARBONATE DUST TREATMENT

A full-strength copper carbonate dust (about 50-percent copper), manufactured especially for seed treatment, should be applied at the rate of 2 to 2½ ounces per bushel of well-cleaned seed. The seed and the dust should be mixed in a tight mixing machine until every kernel is thoroughly covered. Seed thus treated may be stored indefinitely, without injury to germination. With this chemical, care must be used to avoid damage to the grain drill. Sometimes there is a tendency for the treated seed to cake in the drill when standing overnight or longer in damp or wet weather. In such cases it is advisable to rock the drill wheels back and forth before starting, in order to avoid breaking or bending the working parts. All working parts of the drill should be kept well oiled. The treated grain should be well cleaned out of the drill when seeding is completed to avoid corrosion of the parts. Seed treated with copper carbonate should not be fed to farm animals.

ETHYL MERCURY PHOSPHATE DUST TREATMENT (NEW IMPROVED CERESAN)

Ethyl mercury phosphate dust, manufactured especially for seed treatment, should be applied at the rate of one-half ounce per bushel in a mixing machine, or as recommended in directions on the container. The dusted grain should be kept in a bin, pile, wagon box, or sacks for at least 10 hours. During this period the grain should remain uncovered. Treated grain may then be seeded at once, or it may be stored for not longer than 4 weeks. Ordinarily grain should not be treated more than 4 weeks before seeding because of uncertainty as to the effect on seed germination after this period. This treatment has the advantage of being applicable to wheat, oats, and barley, is easily applied, does not cake in the drill, and is noncorrosive to drill parts. As in the case of copper carbonate, seed treated with this chemical should not be fed to farm animals. Do not apply more than one-half ounce of this disinfectant per bushel of wheat. An excess may injure germination.

BASIC COPPER SULPHATE DUST TREATMENT

Basic copper sulphate dust (about 50-percent copper), manufactured especially for seed treatment, should be applied at the rate of 2 to 2½ ounces per bushel of well-cleaned seed, and mixed as outlined above for the copper carbonate treatment.

Caution.—Copper carbonate, ethyl mercury phosphate (New Improved Ceresan), and basic sulphate dusts are POISONOUS. Therefore, the inhaling of these compounds should be avoided. Treat seed in a well-ventilated place or outdoors. Wear a dry cloth or a dust mask over the nose and mouth. Avoid taking New Improved Ceresan in the hands or letting it otherwise contact the moist skin as it may cause blistering. Handle it in special spoons provided for the purpose, and handle Ceresan-treated grain in tight bags.

SEED-TREATING EQUIPMENT

Equipment for applying dusts to seed grain ranges all the way from home-made hand mixers (figs. 41, 42) operating at the rate of 25 to 30 bushels an hour to commercial, automatic power-driven, and gravity-type mixers, handling 200 to 500 bushels per hour. A grav-

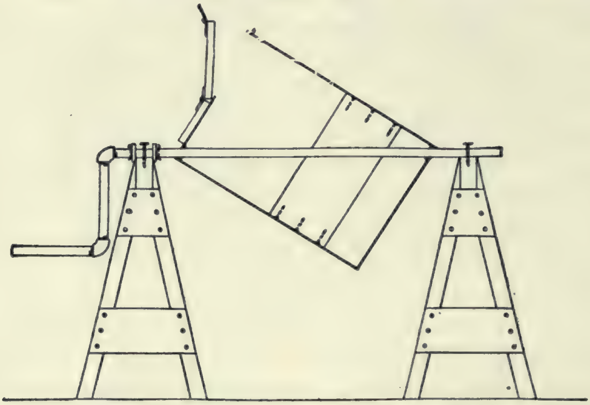


FIGURE 41.—An oil-drum mixer for treating seed wheat with copper-carbonate dusts. (Designed by R. S. Kirby, Pennsylvania State College.)

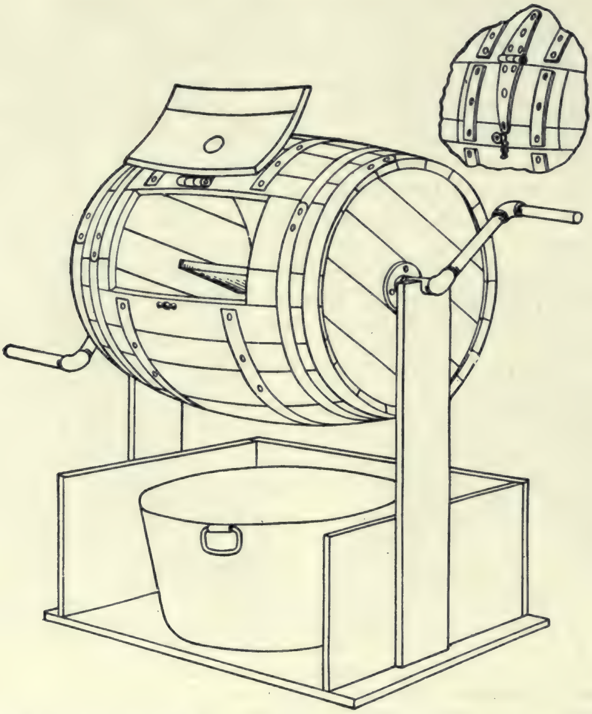


FIGURE 42.—A barrel mixer for treating seed wheat with copper-carbonate dusts. (Designed by F. W. Oldenberg, University of Maryland.)

ity-type mixer is shown in figure 43. Such a mixer is suitable only for the application of a volatile dust, such as New Improved Ceresan. For copper carbonate and basic copper sulphate, a mixer similar to those shown in figures 41 and 42 is required in order to insure a satisfactory coverage of the grain. In using the gravity-type (fig. 43) the disinfectant is applied gradually at the rate of one-half ounce per bushel as the seed grain is poured into the hopper. For this purpose a half-ounce measure is supplied by the manufacturers of the disinfectant so that the latter may be handled without coming in contact with the hands of the operator.

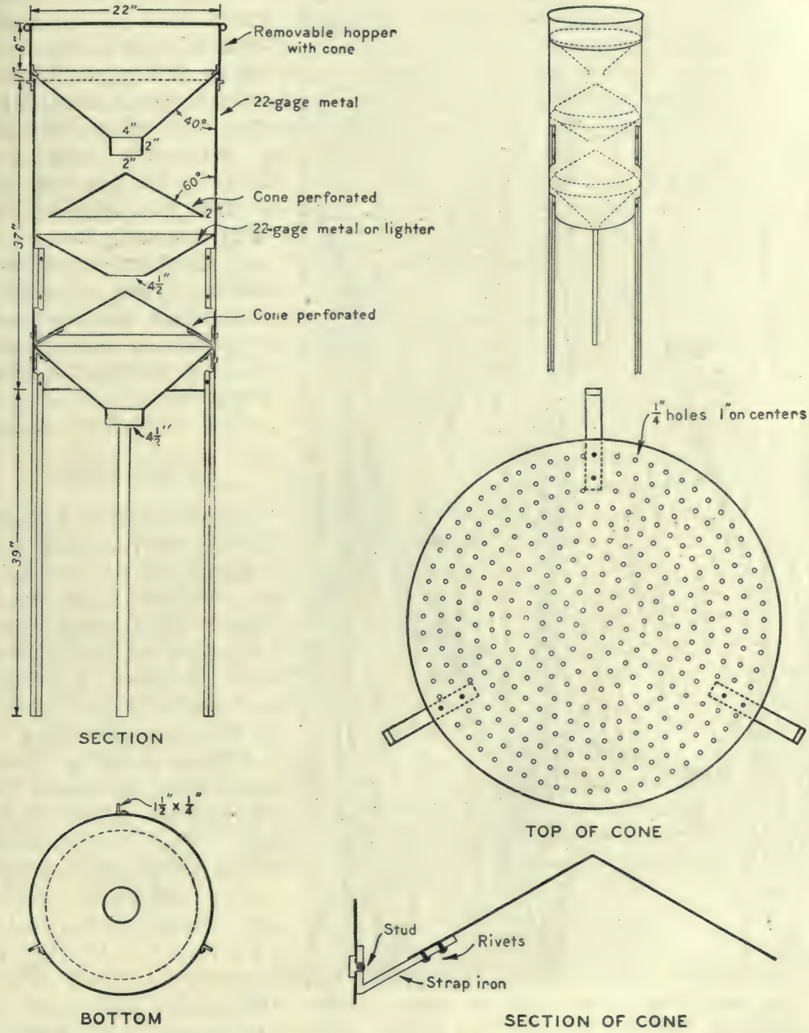

22"
6"
1"
37"
39"
Removable hopper with cone
22-gage metal
40°
4"
2"
2"
60°
Cone perforated
2"
22-gage metal or lighter
4½"
Cone perforated
4½"
SECTION
¼" holes 1" on centers
TOP OF CONE
1½" × ¼"
BOTTOM
Stud
Rivets
Strap iron
SECTION OF CONE

FIGURE 43.—A gravity mixer for treating seed wheat with New Improved Ceresan. Not suitable for copper carbonate or basic copper sulphate.

Large-scale seed treatment by local elevators, seed houses, central treating plants, or portable treating outfits is practical and valuable and is increasing in popularity. By means of it farmers can be relieved of the inconvenience of treating, and a more uniform and satisfactory job of treating can be done. The task is much easier now than it was several years ago. New materials, methods, and equipment make it possible to treat seed rapidly and effectively at a very low cost per bushel. If it is not desirable to purchase a large-capacity commercial machine, there are several types of apparatus that can be constructed by local carpenters or sheet-metal workers to handle 200 to 500 bushels an hour.

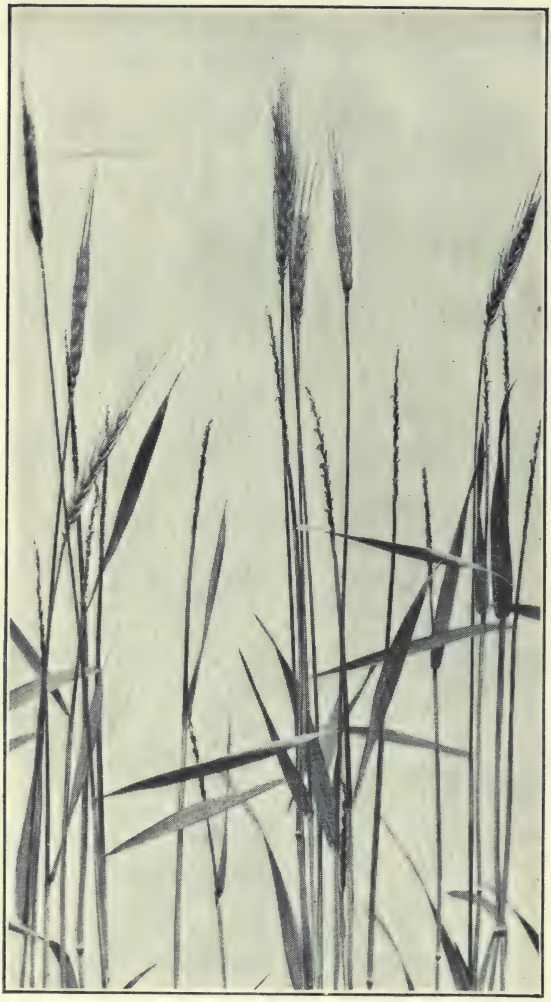


FIGURE 44.—Loose smut in wheat: The infected plants are shorter than the noninfected plants and the glumes (chaff) and grain have been replaced by the black spores of the smut fungus.

LOOSE SMUT

Loose smut is almost always prevalent in the wheatfields of the eastern United States and causes an average loss in yield of about 1.5 percent. Losses in individual fields may amount to 30 percent or more.

Loose smut is very noticeable as soon as the wheat heads (fig. 44). The glumes and other floral parts of the newly emerged heads are almost completely replaced by black masses of smut. For this reason loose smut is frequently called blackhead. The spores are loosely held in the smutted heads and are soon carried away by winds, rain, insects, or other agencies. After the smut is gone only the inconspicuous central stalk (rachis) of the head remains. Some of the spores, in the course of their dissemination, are carried to the flowers within the glumes or chaff of the sound wheat heads. Here the spores germinate and produce an internal infection of the developing kernels. When mature, the infected kernels cannot be distinguished from noninfected kernels. However, if the former are used for seed without being treated, the internally borne fungus starts growing as the kernel germinates and spreads upward into the plant as it develops. Finally when the heads appear, they are composed of the smut masses described above.

Because the loose smut organism invades the internal parts of the kernel, the disease cannot be controlled through treating the seed with the easily applied surface disinfectants, as described for bunt. It may be effectively controlled by employing what is known as the modified hot water method. This treatment is recommended only for a sufficient quantity of seed to sow a plot distant from the main crop that will serve as a source of clean seed for the following year. It is difficult to apply, however, even to small lots of seed and has not proved popular with growers. In general, therefore, when loose smut becomes important, the best method of combating it is to secure seed from a smut-free field. If it seems desirable to apply the modified hot-water method, directions may be obtained from the State agricultural experiment station or from the United States Department of Agriculture.

FLAG SMUT

Flag smut occurs only to a limited extent in Illinois, Missouri, and Kansas. On susceptible varieties it may cause losses of more than 30 percent, but of plants of the relatively resistant varieties now being grown in most of the infested areas, not more than 1 to 5 percent usually are infected.

Flag smut produces dark stripes in the leaves, sheaths, and stalks. It stunts the plants and usually prevents the formation of normal heads (fig. 45, p. 50). It is carried over from one crop to the next, both with the seed and in the soil of infested fields. It may be controlled most advantageously by the use of adapted, highly resistant or immune varieties of soft red winter wheats, such as Trumbull, Fulhio, Kawvale, and Fulcaster, or hard red winter wheats such as Cheyenne, Kanred, Turkey, Tenmarq, and a number of resistant hybrids.

If susceptible varieties are desired, such as unselected Harvest Queen, the seed should be very thoroughly cleaned and carefully treated with copper carbonate or New Improved Ceresan, and sown on noninfested land.

SCAB

Scab occurs most commonly in the Corn Belt, where occasionally it takes a very heavy toll. Some years it is severe also in the east-central States.

The scab fungus attacks the seedlings and also the heads of the plants. The attacked seedlings are killed or greatly weakened, and the attacked portions of heads are killed. Individual spikelets or various portions of heads may also be killed (fig. 46, p. 51). Usually some pink or salmon-colored masses of spores of the scab fungus are evident at the edges or bases of the affected glumes. The kernels in killed portions become much shrunken, almost white, and scabby in appearance. Hence the name "scab."

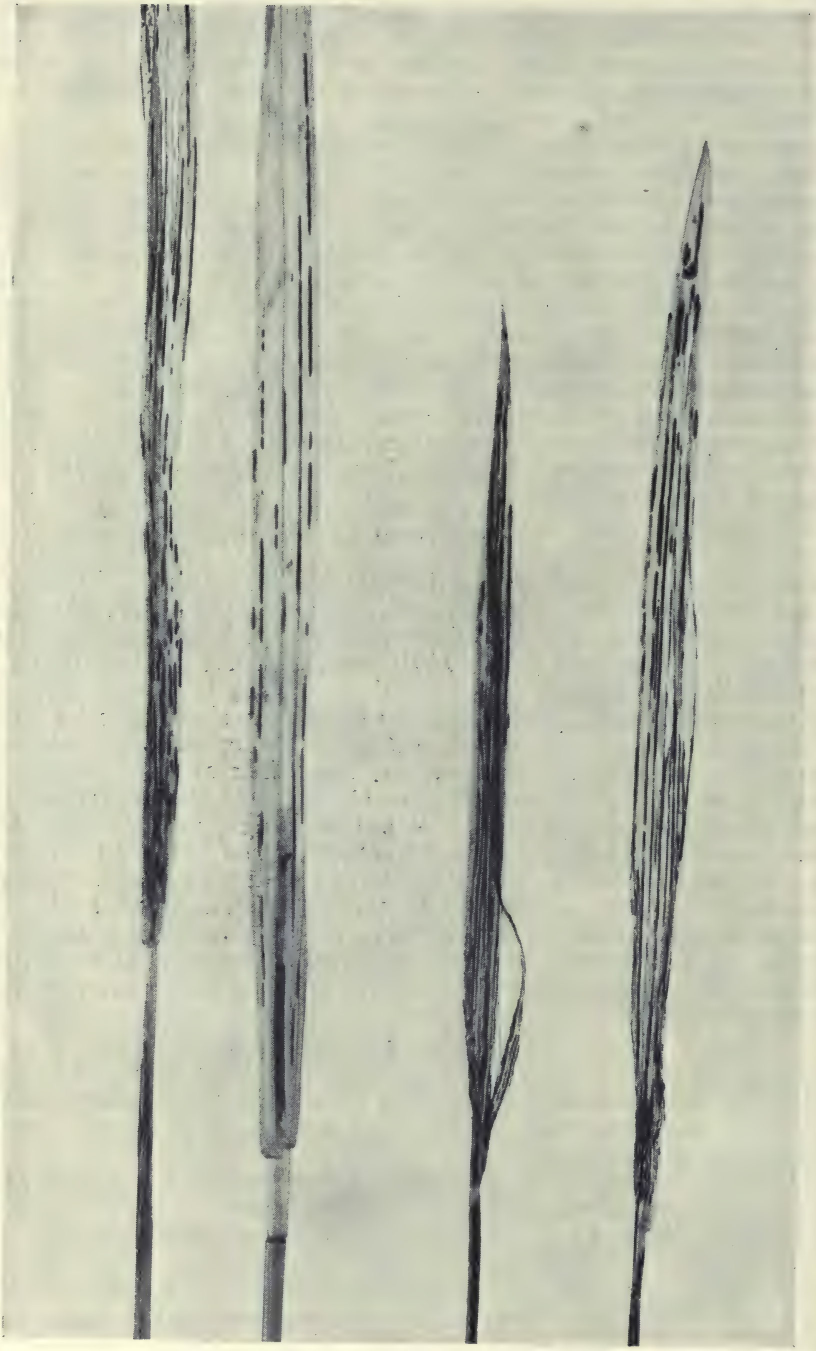


FIGURE 45.—Flag smut in leaves and stalks of wheat.

The scab fungus is carried over from one crop to the next, both with the seed and on old crop refuse, such as cornstalks in the field. The fungus carried with the seed infects the wheat seedlings more or less severely, depending on various conditions at seeding time, and causes seedling blight. The fungus from old cornstalks, if left in the surface of the soil, may infect the heads and cause head blight. It is for this reason that the disease is most severe where wheat follows corn.

Scab is difficult to control. In areas where it is frequently severe, the most effective control is secured by sowing wheat on land other than cornland. Where this is not possible and it is necessary to use the cornland for wheat, the cornstalks either should be very thoroughly plowed under or cut as low as possible and the land very thoroughly disked. In the latter case, all fodder and loose cornstalks should be removed from the fields before the wheat comes into head. In any case the seed should be thoroughly cleaned and treated with New Improved Ceresan before sowing.

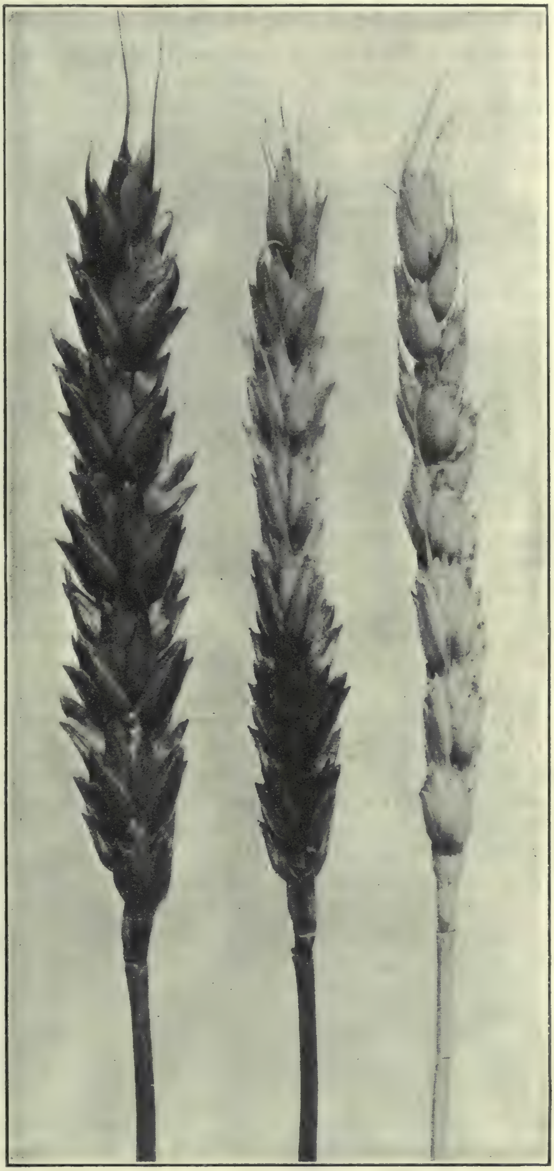


FIGURE 46.—Scab, or blight, on wheat heads: A healthy head (left); part of a head killed (center); the entire head killed (right).

Some progress is being made in the development of wheat varieties resistant to scab, but much remains to be done in this direction before the desired resistance is obtained.

TAKE-ALL

Take-all has been reported from the following States in the eastern half of the United States: Kansas, Arkansas, Indiana, Tennessee, North Carolina, Virginia, Maryland, and New York. It is most important in Kansas and New York. In the other States it has been of minor importance in recent years. In Kansas, in some years, it destroys 10 to 50 percent of the crop in infested fields. Fortunately, infested fields are comparatively few; but, because of possible heavy losses from the disease, it should be carefully watched.

Take-all may kill the plants in the rosette stage; it may so dwarf them that only a few low culms with small heads are formed, or it may kill plants that have attained about the normal size as the heads are beginning to fill. Such plants turn almost white; therefore this development of the disease is sometimes called white heads. Nearly all the plants in certain spots or only a plant or two in a place, variously scattered in the field, may be killed, and various intergrading conditions may occur. In any case the bases of the infected plants usually are black to a height of 1 or 2 inches above the soil, and the plants pull up rather easily because of the rotted, infected roots.

The take-all fungus is not carried with the seed but persists several years in the soil. The only feasible control measure known is to keep wheat, barley, and rye off infested land for about 4 years. In the meantime apparently it is advantageous to plow under some green-manure crop, particularly sweetclover if this is feasible. No resistant varieties are known.

MOSAIC

There are several closely related mosaic diseases of winter wheat in the eastern United States. In the most susceptible varieties, losses up to 75 percent or more may occur in extreme cases.

Wheat mosaic may affect different varieties somewhat differently. On the most susceptible varieties, such as Harvest Queen, extreme dwarfing or rosetting (fig. 47) and also leaf mottling may occur. On other varieties, only the leaf mottling occurs.

The mosaic diseases are caused by viruses, which may persist in the soil for several years. Therefore, susceptible varieties should not be sown in soil known to be infested. The safest procedure, where the disease occurs, is to use only varieties known to be resistant.

While Harvest Queen is one of the most susceptible varieties, resistant strains that are satisfactory have been selected from it. Most winter wheat varieties that have been tested are resistant to mosaic rosette but susceptible to mosaic mottling in different degrees of severity. Selections from certain standard varieties have shown immunity from mosaic rosette and high resistance to mosaic mottling.

NEMATODE DISEASE

The nematode disease occurs to some extent in Maryland, Virginia, West Virginia, North Carolina, South Carolina, and Georgia. Losses on individual farms may range from very slight to as much as 70 percent. The disease occurs on both wheat and rye and is caused by a species of very small roundworm, called nematode or eelworm, which in the wheat heads forms galls instead of kernels. An infected head of wheat and some nematode galls are shown in figure 48.

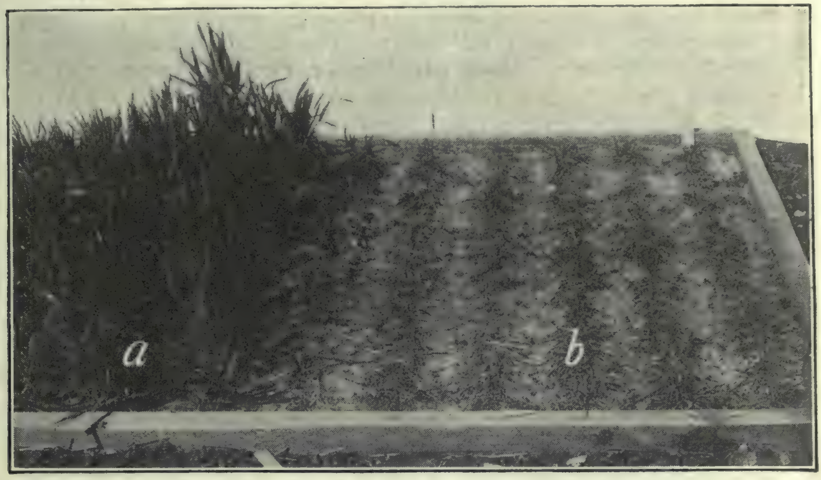


FIGURE 47.—Harvest Queen wheat selections grown in virus-infested soil: The six rows at *b* were a strain selected for high susceptibility to mosaic rosette; the two rows at *a* were a strain selected for resistance to mosaic rosette.

The nematode is carried over from one crop to the next in galls with the seed or in infested soil. The disease may be controlled by using noninfested seed on noninfested soil. It is extremely difficult to remove nematode galls perfectly from seed wheat. Therefore it is usually best to secure seed that is known to be free from them and to sow it on land that has neither grown nematode-infested wheat or rye for 1 year, nor had infested manure or infested crop refuse spread on it for 1 year.

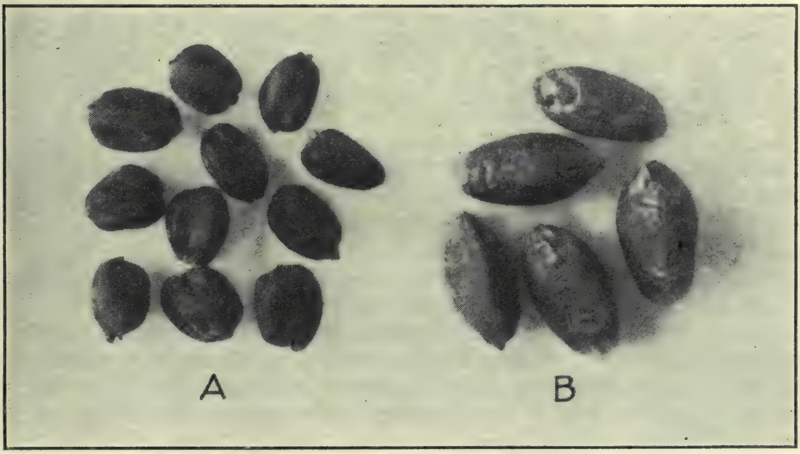


FIGURE 48.—*A*, Nematode galls; *B*, normal wheat kernels.

WEEDS IN WHEAT[1]

Weeds are often a serious problem in wheatfields in the eastern United States. The most serious are those, like the European or field bindweed, Canada thistle, and wild onion or wild garlic, that live from year to year by virtue of underground stems or bulbs in which reserve foods are stored to carry the plants through unfavorable periods of the year. Such plants are commonly known as perennials. They are regarded as the most serious because they are most difficult to eradicate or control. They occur not only in wheat but in other crops as well. Fortunately, with the exception of wild garlic, they are not widespread in the eastern United States, although elsewhere they occupy thousands of acres of valuable land, and in some cases are so serious as to make the profitable production of crops out of the question. A second important class is the winter annuals, such as chess or cheat, corncockle, dogfennel, chickweed, and skeletonweed, that start growth in the fall with the wheat and mature the following year. Such weeds are troublesome, but usually they can be controlled or completely eradicated by good farming methods.

Wild garlic or wild onion probably is the most objectionable weed in eastern wheatfields. The plant grows from underground bulbs and also from aerial bulblets which ripen with the wheat. The green bulblets are very difficult to separate from wheat, but they shrink during storage and if thoroughly dry may be removed by means of the fanning mill or other cleaning equipment. If not removed, they form gummy masses on the rolls in milling and impart a strong odor of garlic to the flour.

In the official grain standards of the United States, wheat containing two or more green garlic bulblets or their equivalent in approximately 2 pounds of wheat is specially designated as "Light garlicky" or "Garlicky." Such wheat is discounted in price. Wild garlic is a very difficult weed to exterminate, and every effort should be made to keep it off the farm. Those who wish to attempt to eradicate or control it will find further information in United States Department of Agriculture Leaflet 43, Wild Garlic and Its Control.

Cheat or chess is one of the most common weeds in wheatfields in the eastern United States. It is a species of bromegrass and not, as commonly supposed, a degenerate form of wheat. The plant is more hardy than wheat, a fact which sometimes causes fields of wheat apparently to change to cheat over winter. The seeds of cheat are difficult to remove from wheat and are often sown with it, thus perpetuating the cheat from year to year. However, it is possible to remove cheat seed from wheat by careful adjustment of the fanning mill, and when this is done and a good farming system including rotation of crops is used, there is not likely to be serious trouble from this pest. Fortunately the seeds of cheat do not live long in the soil.

Corncockle or purple cockle is often found in fields of winter wheat in the eastern United States. The rough, dark-colored seeds are difficult to separate from wheat if present in appreciable quantities and produce a dark, bad-flavored flour of poor quality. Also the cockle seeds are reputed to be poisonous to poultry. The seeds do not live long in the soil, and the use of clean seed, together with careful cultivation and suitable rotations, will eradicate the pest.

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[1] Contributed by L. W. Kephart, senior agronomist, Division of Cereal Crops and Diseases.

Dogfennel, chickweed, skeletonweed, wintercress, and similar weeds, if they occur in large numbers, crowd the stand of winter wheat and may reduce the yield seriously. With the exception of chickweed and wintercress, they are likely to be less troublesome in late seedings than in early ones. They also can be controlled by good farming methods.

INSECTS THAT ATTACK WHEAT[2]

HESSIAN FLY

In the principal areas where soft red winter wheat is grown the hessian fly (*Phytophaga destructor* (Say)) is without doubt its most formidable insect enemy. A portion of a wheat plant infested with hessian fly maggots is shown in figure 49. The most important and practical means of control for this pest, as indicated on page 37, is to plant winter wheat at a date that will delay the appearance of the young wheat above ground until after the main brood of flies has emerged and died. Sound cultural practices that contribute to the vigor of the growing crop are an important help in combating the hessian fly. Chief among these are the sowing of good seed, the proper fertilization of the soil, and a well-prepared, firm seedbed.

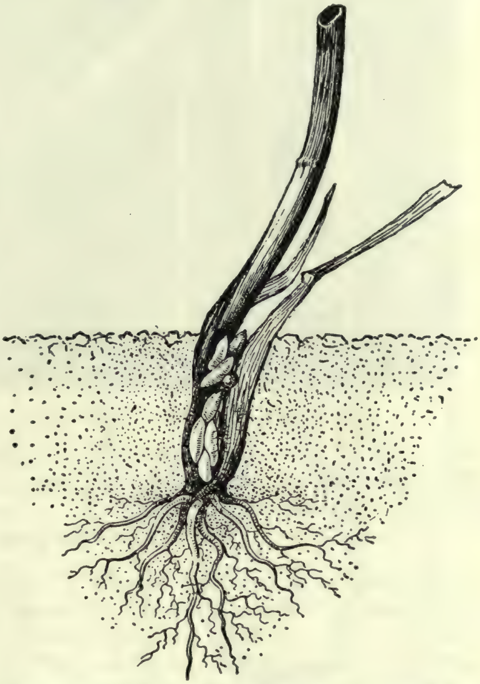

FIGURE 49.—Hessian-fly maggots beneath leaf sheath in the soil. (× 1.)

WHEAT JOINTWORM

The wheat jointworm (*Harmolita tritici* (Fitch) is considered one of the most consistently injurious insect enemies of the soft wheats in the East Central and Atlantic States. The way the wheat jointworm attacks the plant is illustrated in figure 50. Its work usually remains undetected, and losses caused by it are often attributed to unfavorable weather or cultural conditions. It robs the heads of nourishment by causing hard knots or galls in the stems. Where very abundant, it may cause lodging of the ripening grain and thus call attention to its presence. Jointworm may be controlled by cutting the wheat as high as practicable and plowing under the stubble immediately after harvest in order to bury it so that the jointworm adults cannot emerge. This, of course, is not generally practicable where grass, clover, or other legume is seeded with the wheat, except in cases of extremely heavy infestation. Farmers' Bulletin 1006, The Wheat Jointworm and Its Control, contains additional information on this insect.

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[2] Contributed by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

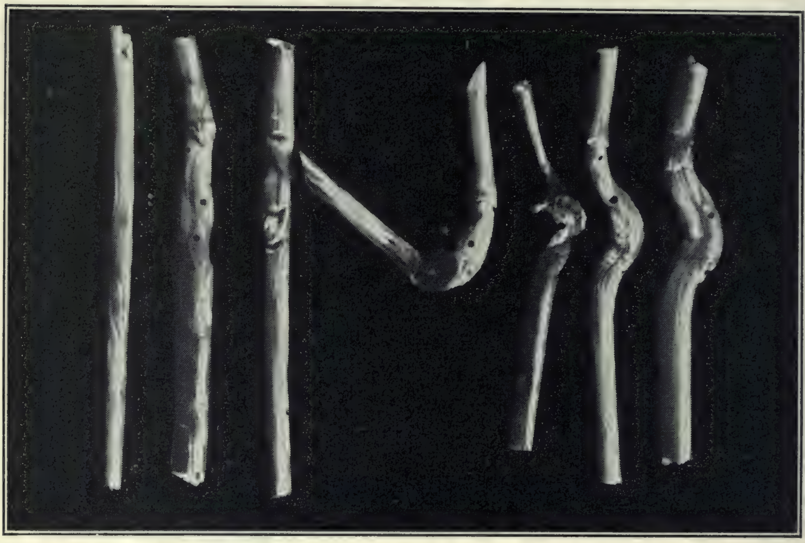

FIGURE 50.—Work of the wheat jointworm. (Natural size.)

SAWFLIES

The black grain-stem sawfly (*Trachelus tabidus* (F.)) and the European wheat-stem sawfly (*Cephus pygmaeus* (L.)) occur in the North Atlantic States, the first-named species having recently spread into and become a serious wheat pest in eastern Ohio.

Where the sawflies have become abundant, serious losses are likely as a result of the breaking-over of straws, shattering of grain, and difficulty of harvesting.

The sawfly larva is a yellowish-white worm with a brown head, which develops from an egg laid by a small wasplike insect inside the wheat stem about the time of heading. The worm feeds inside the stem and gradually works its way downward until by harvest-time it has become full-grown and about three-eighths of an inch long. It then cuts a ring almost through the stem wall close to the ground, leaving just enough outside fiber intact to hold the stem erect until it can securely plug the end of the stub, in which it forms a resting cell. As the stem dries and becomes brittle, the weight of the head, together with wind or rain, causes the stem to break off close to the ground, where the worm has cut around it inside. The larva remains in the stub until the following spring, when it changes to the adult-wasp stage and emerges to lay eggs in the currently maturing crop.

No entirely satisfactory method of controlling sawflies is known. Plowing under stubble at least 6 inches deep with thorough coverage, where possible, before the spring emergence of the adults, is beneficial. However, this practice would have to be followed throughout whole communities to be materially effective. Furthermore, it conflicts with the well-established and desirable practice of planting clover or timothy in the wheat.

Two other helpful measures are recommended in heavily infested areas. Thorough cultivation and fertilization to produce a strong, heavy stand help materially to reduce loss; and cutting the wheat as early as possible before it has a chance to break over as a result of sawfly injury prevents losses due to lodging and shattering.

CHINCH BUG

Although the chinch bug (*Blissus leucopterus* (Say)) has long been known as a principal insect enemy of wheat, this evil reputation has not been justified by its behavior during the past 25 years in soft red winter wheat. Chinch bugs do feed on and deposit eggs upon these wheats, but their vigorous growth and early maturity force the bugs to migrate to corn, usually before serious injury has occurred to the wheat. In the spring the bugs tend to congregate in the thinner, poorer parts of the fields and in years of extreme abundance often kill or greatly reduce the growth of the wheat in such areas. A heavy stand of soft red winter wheat is seldom seriously injured by chinch bugs; this is fortunate, as no thoroughly satisfactory method of protecting this crop has yet been devised. Promoting a heavy, thrifty stand of wheat, preferably intermixed with clover, is a good protective measure.

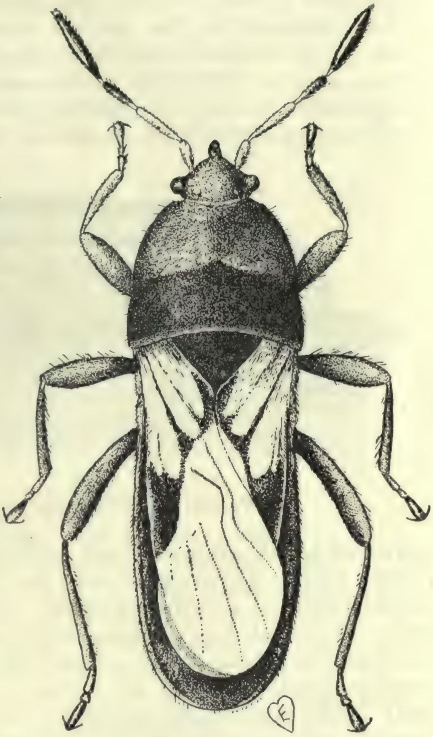

FIGURE 51.—An adult chinch bug. (× about 19.)

In years of abundant chinch bugs, spring wheat grown within the range of chinch bug infestation is almost certain to be seriously damaged. Its younger stage of growth at time of infestation and longer period of succulence thereafter render it most attractive to the bugs. An adult chinch bug is shown in figure 51.

The practice of winter burning of the grasses and leaves in which it hibernates, often advocated for the control of chinch bugs in the hard wheat region, is not generally advisable in the main area devoted to soft red winter wheat production. Under ordinary conditions not more than 25 percent of the bugs can be killed in this way, and as a rule there are serious disadvantages in this operation. Where it is possible safely and effectively to burn a limited area known to harbor large numbers of bugs, this should be done, either early in the winter after all the bugs have congregated in the grasses or before the first warm spell in spring, prior to the first flight of bugs. Farmers' Bulletin 1780, How to Fight the Chinch Bug, contains further information regarding the chinch bug.

ARMYWORM

In years favorable to its development, the armyworm (*Cirphis unipuncta* (Haw.)) (fig. 52) sometimes inflicts serious and widespread damage on the winter wheat crop. This is most likely to occur in the southern halves of the East Central and Middle Atlantic States, and to follow the occurrence of a mild, open winter that has merged into a cold, wet spring. Ordinarily, the armyworm is effectively suppressed by its numerous natural enemies, but the foregoing meteorological sequence may permit it to escape them and do great injury to the growing wheat. In this case the prompt distribution of poisoned bran bait is advised. The formula is as follows: Wheat bran, 50 pounds; paris green or crude arsenic, 2 pounds; blackstrap molasses, 2 quarts; water, 6 gallons. Mix the bran and poison thoroughly together while dry; then add the diluted molasses and stir well until thoroughly mixed. Broadcast the bait thinly, not in lumps, over the infested field late in the afternoon.

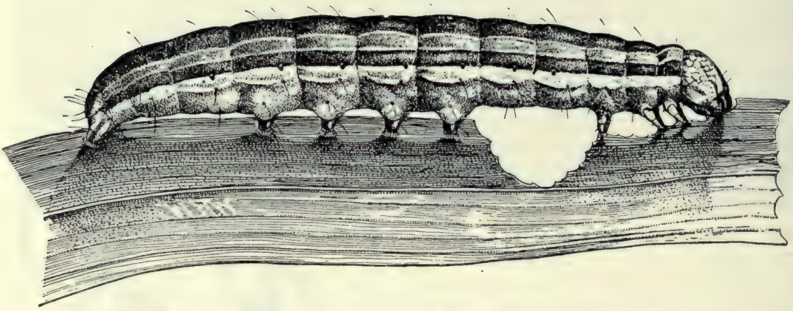

FIGURE 52.—An armyworm larva. (× about 3.)

In its early stages, the armyworm usually works concealed among the lower leaves of the grain, and frequently its presence remains undetected until it has developed to a large size and is doing great damage to the heads of the grain. Its early detection is necessary to prevent serious loss.

Other insects sometimes seriously injurious to winter wheat are the green bug, sod webworms, and wireworms. For information regarding these and other insect pests of wheat, apply to the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C.

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U.S. DEPARTMENT OF AGRICULTURE

MECHANICAL MILK COOLING ON FARMS

FARMERS' BULLETIN
No. 1818

THE INCREASED DEMAND for high-quality milk by consumers and the increasingly strict requirements of local and State health departments in regard to the production and handling of milk have led to a great increase in the use of mechanical refrigeration on dairy farms. Although ice, if available in sufficient quantities, will cool milk and hold it at sufficiently low temperatures, it lacks the advantage of automatic operation to be had with electrically driven milk-cooling units or semiautomatic in the case of most other power units.

The increase in the percentage of farms served with high-line electricity from 2.7 percent in 1924 to 17.5 percent in 1937 has stimulated the use of electric refrigerating outfits.

To save useless expense, a refrigerating machine with its storage tank or box should be large enough to take care of the greatest daily production of milk but no larger. The refrigerating unit itself should be large enough to supply the total amount of refrigeration needed each day in from 10 to 12 hours of operation.

No amount of refrigeration, however, will take the place of care in cleaning the barn, the milk room, and the utensils used in handling the milk. Refrigeration merely keeps the milk in its original state; it does not eliminate bacteria.

Washington, D. C. Issued December 1938

MECHANICAL MILK COOLING ON FARMS

By J. R. McCalmont, *assistant agricultural engineer, Division of Structures, Bureau of Agricultural Engineering*

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INTRODUCTION

MECHANICAL REFRIGERATION for cooling and storing milk on farms has increased rapidly in recent years. There are now on the market many small refrigeration machines suitable for use where electric power is available. Where electric power lines are not found, refrigerating units may be powered by gasoline motors. Some units using kerosene for power are also available. These machines can be obtained, with or without the storage unit, in sizes suitable to any dairy farm.

To obtain definite information on what dairy farmers in general may expect from small refrigerating machines, a study was made at 44 dairy farms in Maryland and Virginia where electric cooling outfits of various types were in use. The amount of milk handled ranged from 15 to 200 gallons per day per farm. The study covered methods of arrangement and operation, power consumption, cost of equipment and repairs, and efficiency of the different outfits in comparison with each other. The results obtained on these farms have already been given in Circular 336, Cooling Milk on the Farm with Small Mechanical Outfits. These results, along with observations of methods, and equipment used in representative dairy sections of the country east of the one hundredth meridian, are presented and discussed in this bulletin, with suggestions for effective arrangement and operation. Plans are also included for an inexpensive home-made storage tank and a refrigerator box. Such a tank or box, if properly constructed, is as efficient as a factory-built tank and is often cheaper.

COOLING DELAYS CHANGES

As drawn from the udder, milk is an ideal food for many kinds of bacteria, and its temperature is right for their rapid development. Unless bacterial growth is checked, undesirable changes may take place in the milk causing off flavors and odors or souring. Cold is the chief factor used on the farm to prevent the growth of bacteria in milk.

For example, in one experiment milk with a bacterial content of 16,000 per cubic centimeter kept sweet for about 36 hours when held at a temperature of 75° F., 80 hours when held at 55°, and 180 hours when held at 40°. Bacterial off flavors may develop at any temperature, but they develop more rapidly at the higher temperatures. In other words cooling delays changes in the milk which affect quality and palatability and helps to maintain its original quality. High-quality milk doubtless helps to increase and stabilize the market for milk. Therefore it is of the utmost importance that milk be promptly cooled to and stored at a temperature of 50° or lower.

No means of cooling milk will offset carelessness in production and handling. The same attention to sanitation should be given when mechanical refrigeration is used as is necessary with any other means of cooling.

THREE MEANS OF COOLING MILK

On farms milk is cooled in one of three ways—by water, ice (either natural or artificial), or mechanical refrigeration.

Water from wells, springs, or supply tanks, even under the best conditions, is usually not cold enough to cool the milk below 50° F. in warm weather. There are difficulties in using water alone in storing milk, so that its use is limited to sections where a large supply of cold water can be used without fear of water shortage. The use of ice or mechanical refrigeration is therefore resorted to for cooling and storing milk on most farms during warm weather in order to get temperatures low enough to control bacterial growth. Where ice is employed on the farm for cooling and storing milk, a tank in which ice and water form the cooling medium is generally used. This type of storage is known as the wet tank. On producer-distributor farms where milk is bottled, dry-box storage with ice as the cooling medium may be used, but on other types of farms this system is not so practical.

The use of water and of ice for cooling milk on dairy farms is discussed more fully in Farmers' Bulletin 976, Cooling Milk and Cream on the Farm.

Either wet-tank or dry-box storage can be operated economically with mechanical units. Where wet storage is used with mechanical units, the evaporating coil[1] for absorbing the heat is placed in the water in the storage tank. Where dry storage is used, the cooling medium is usually a brine solution confined in an iron or copper tank within the storage box. The evaporating coil is located in the brine tank, and by absorbing heat from the brine keeps it chilled. In wet storage there are only two transfers of heat, namely, from the milk to the water in the storage tank, and from the water to the coils; whereas in dry storage there are three transfers of heat; that is, from the milk to the air in the box, from the air to the brine solution, and from the brine to the coils. The extra heat transfer along with the fact that air is not so efficient as water in transferring heat, makes the operating cost of dry-box storage higher than that of wet-tank storage. The average amount of electric power used to cool 1 gallon of milk 1° F. on 27 farms having wet tanks was 4.6 watt-hours, and on 7 farms having dry boxes it was 5.8 watt-hours.

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[1] So-called because in it the refrigerant is permitted to evaporate in order to absorb heat from the surrounding water or air (p. 3).

WHY MECHANICAL COOLING IS INCREASING

The rapid increase in the use of refrigerating machines on dairy farms is due chiefly to (1) improvement in the machines, (2) the extension of electrical lines into the country and reduced cost of electricity, (3) irregular deliveries of ice, (4) saving in labor, and (5) regulations of health departments.

Manufacturers of refrigerating machinery have made great progress in recent years in developing the small self-contained compression machines which are almost universally used for small-scale mechanical refrigeration. The principal parts of such an outfit are the compressor and motor, condensing coils, evaporating or cooling coils, and the storage tank or box. In these machines much improvement has been made in the compressor, the expansion valve, and thermostatic or pressure temperature controls.

The rapid extension of electrical lines into the country has made the use of electric refrigerating machines possible on many farms. In 1924 only about 2.7 percent of the farms in the United States were served with high-line electricity; in 1932, 11 percent, and in 1937 17.5 percent.

In sections where farmers use manufactured ice, irregularity of delivery has turned many to the use of refrigerating machines. A long period of farm-labor scarcity following 1917 was also a factor in bringing more of them into use.

Health-department regulations also have helped to bring about a change in refrigerating methods. In most markets over which public-health authorities have control it has been the practice to set a maximum temperature for the milk when it reaches the city market. The temperature requirements are becoming more rigid all the time, and in some cities the maximum allowable temperature is as low as 40° F. Although these temperatures can be attained with ice, an abundant supply must be present at all times. The ice takes up extra room in the tank, and the dairyman must keep a watchful eye to see that the amount is sufficient to maintain the required temperature. Mistakes in judging the right amount of ice may lead to poor-quality milk.

TYPES OF REFRIGERATING MACHINES

The refrigerating machines observed under actual working conditions and discussed herein were compression machines, all driven by electric or gasoline motors. All machines worked on the same principle, although sulphur dioxide, methyl chloride, or ammonia were used as refrigerants in different machines. These machines cool by alternately vaporizing and condensing a volatile liquid. Ammonia, sulphur dioxide, methyl chloride, and similar volatile liquids evaporate at ordinary room temperatures when not under pressure, but condense again into liquid form on being compressed and again cooled to room temperatures. The liquid is permitted to evaporate in the coil in the brine or cooling tank, and in doing so it absorbs heat from the surrounding water or air. The gas is then compressed, cooled by the air or water circulating around the condensing coils, and becomes a liquid. It is then in condition to be evaporated again, and absorb more heat from the tank or box.[2]

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[2] For more complete information on refrigeration *see* Refrigeration in the Handling, Processing, and Storing of Milk and Milk Products, Misc. Pub. 138. For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., for 10 cents.

COST OF OUTFITS

The cost of outfits was obtained on 50 farms. On 38 of these farms a complete outfit had been purchased, including the mechanical unit (compressor, condenser, and motor), a manufactured cooling tank or box, coils, and a circulating pump with its motor or an agitator. In this group the cost of the complete outfit per cubic foot of storage capacity averaged $15.14 and ranged from $10.40 to $30.50 per cubic foot. Twenty-four outfits, or 63 percent of those in this group, cost between $10 and $15 per cubic foot, and 10 outfits, or 26 percent, cost between $15 and $20 per cubic foot.

In 11 cases no tank or box was purchased with the outfit, and the cost of the tank or box was not obtained. For this group the average cost of the mechanical outfit per cubic foot of storage space was $13.30, with a range from $8.80 to $21.20. For eight plants, or 73 percent of this group, the cost was between $8 and $15 per cubic foot of storage.

In table 1 the cost of the complete outfits is figured on the basis of the rated storage capacity in 10-gallon cans. It is interesting to note that the average price per outfit shows a decrease of from 1 to 50 percent between 1928–31 and 1933–37.

TABLE 1.—*Cost of 38 mechanical milk-cooling outfits,*[1] *arranged according to rated storage capacity, for the years 1928–31 and 1933–37*

Farms (number)		Rated storage capacity[2]	Price range (complete outfit)		Average price			
					Per outfit		Per 10-gallon can	
1928–31	1933–37		1928–31	1933–37	1928–31	1933–37	1928–31	1933–37
		10-gallon cans	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
7	3	4	350–500	185–220	410	208	103	52
7	7	6	328–700	350–450	481	389	80	65
6	3	8	485–635	450	554	450	69	56
2	2	10	510–550	495–550	530	523	53	52
1	-------	14	675	-----------	675	-----------	48	----------

[1] 23 of these outfits were purchased during the period 1928–31 and 15 between 1933 and 1937.

[2] Number of 10-gallon cans that can be placed in the tank at one time.

COST OF REPAIRS

The cost of repairs over periods of from 3 months to 9 years was obtained on 44 farms. The machines had an average age of 2 years 8 months. The average cost for repairs was $3.60 a year. Of this group, 27 machines that had been in use from 1 to 9 years, on an average 3 years 4 months, cost $4.70 a year, and 17 machines ranging from 3 months to 4 years in age and averaging 1 year 7 months had required no service at all. Repairs were various, the more common being the regulation of the temperature control, replacing belts, repairing leaks, and adding new refrigerant to replace that lost by leakage. In one case the compressor valves had to be replaced, and in two others motors had to be traded in on new motors or repaired. Some sales firms have a flat yearly service charge for which a repairman will take care of all repair work. The owner generally pays for new parts.

INSTALLATION AND ARRANGEMENT

LOCATION OF THE MACHINE

Mechanical cooling units are usually installed in one of three locations—in the room with the milk-storage tank or box; in a separate room (fig. 1); or outside the milk house, the machine being protected under a shed with lattice work on the sides (fig. 2.)

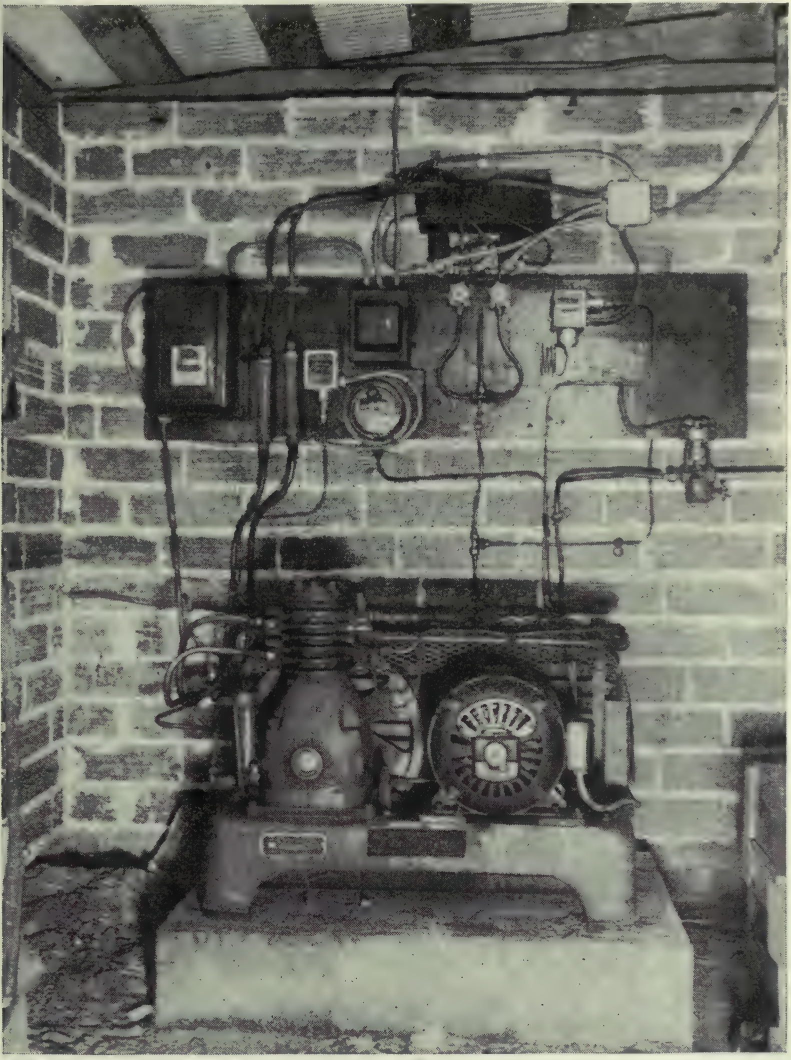

Figure 1.—A compressing unit in a separate room. All the controls are mounted on a panel readily accessible for inspection and care.

These machines should be located in a well-lighted, well-ventilated room separate from the storage or milk-handling room. Nearly all of them are air-cooled, and they tend to circulate dust and to pull it in from outside where the screened opening is provided for ventilation.

If the machine is in the milk room, some of this dust is likely to come in contact with the milk or the utensils. Another objection to having the machine in the milk room is that it generates heat, which at times may raise the air temperature of the room more than 6° F. The machine must not only overcome this additional heat in cooling the milk but also work at a higher temperature, which reduces the efficiency of the condensing unit. The machinery needs oil, and except in the case of hermetically-sealed units it is hard to use oil without dropping some. The older the machine, the more oil leaks out. The dark area in figure 3 is the result of leakage of oil. Machines of this kind should not be placed in a milk room—most certainly not on top of the storage tank.

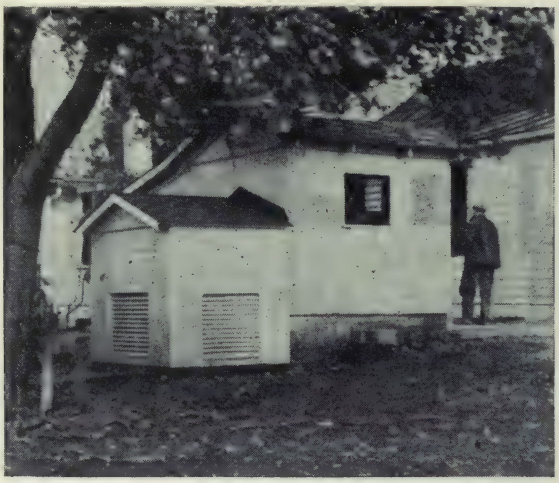

FIGURE 2.—A small shed with latticework sides built next to the milk room to house the compressing unit.

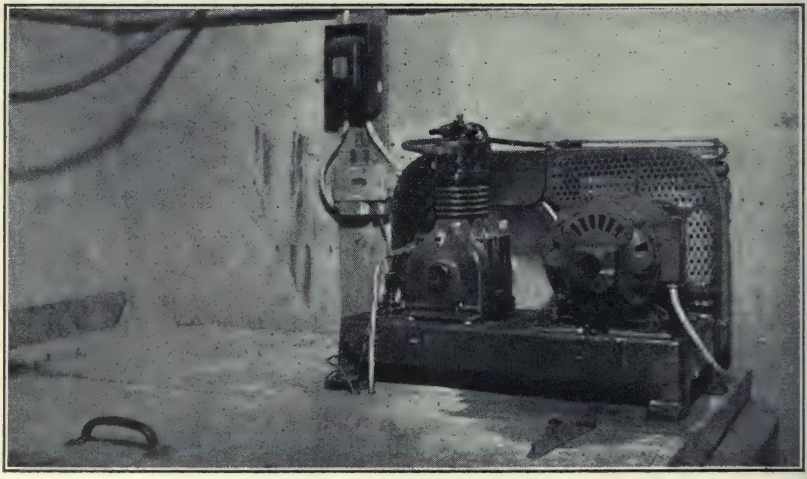

FIGURE 3.—Cooling unit on top of storage box. The dark area on the top of the storage box is oil from the machine.

POWER FOR ELECTRIC-DRIVEN MACHINES

The voltage of power lines supplying farms in the past has been variable. That of the lines furnishing power to the farms where actual tests were made fluctuated greatly, but no cases of injury to motors or equipment due to high or low voltage were observed. However, all equipment should be properly protected by fuses and "inverse-time" protective devices. In most instances the line voltage was low at milking time because of the heavy load thrown on the line at that time by refrigerators, milkers, lights, hot-water heaters, and ranges. On one farm the motor of the refrigerating unit would not start when the electric range was in use. This trouble was found to be due to a too-light service connection rather than to low voltage in the power line. Care should be taken therefore to have the service entrance lines and the wire supplying current to the outfit of sufficient size to eliminate any appreciable line drop and low voltage. Most power companies have trained field representatives to advise the consumer of the proper installations for his individual needs. Electric service is now generally good and free from interruptions.

SIZE OF COMPRESSOR REQUIRED

Theoretically 0.056 pound of ice-melting capacity, or the melting-ice equivalent, as it is known in refrigeration, is required for 1 gallon-degree of refrigeration of 4-percent milk; that is, to cool 1 gallon of 4-percent milk 1° F. Since in a well-constructed storage box used to capacity the milk cooling load is equal to 70 percent of the refrigeration load and the heat loss is 30 percent, the refrigeration required per gallon-degree in ice-melting capacity, would be 0.08 pound.[3] The capacity of the compressor needed can be found as follows: Multiplying the number of gallons of milk to be cooled per day by the number of degrees it is to be cooled by the refrigerating machine gives the total number of gallon-degrees; then multiplying the number of gallon-degrees by 0.08 gives the total ice-melting capacity needed per day. Dividing this amount by the number of hours the machine is to run each day (for example 12 hours) will give the rating of the compressor needed, in pounds of ice-melting capacity or melting-ice equivalent per hour. Table 2 gives the data for a 10-gallon can of milk when cooled from 10° to 60° F.

TABLE 2.—*Total refrigeration required per day per 10-gallon can of milk to be cooled to and stored at 40° F. and the compressor capacity per hour needed to furnish that refrigeration in 12 hours*

Range of cooling temperature (° F.)	Melting-ice equivalent—		Range of cooling temperature (° F.)	Melting-ice equivalent—	
	Per day of refrigeration [1]	Per hour of compressor rating		Per day of refrigeration [1]	Per hour of compressor rating
	Pounds	*Pounds*		*Pounds*	*Pounds*
10	8	0.7	40	32	2.7
20	16	1.3	50	40	3.3
30	24	2.0	60	48	4.0

[1] This column gives the approximate amount of refrigeration or ice-melting capacity required each day of 24 hours and should not be confused with the capacity of a refrigerating machine necessary to furnish this amount of refrigeration in 12 hours' running time.

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[3] For a tank or box that is poorly insulated or too large for the quantity of milk to be cooled, more than 0.08 pound will be required.

The capacity of compressor needed for cooling and storing any amount of milk can be computed readily by multiplying the figures given in table 2 by the maximum number of 10-gallon cans of milk to be cooled. The figures given under refrigeration required per day represent the total amount of ice required to cool and store 10 gallons of milk, while the compressor rating represents the capacity of compressor needed, if it is to run 12 hours per day.

To show the approximate size of motor required to drive a compressor suitable to handle the cooling load in 4-, 6-, 8-, 10-, and 12-can tanks when cooling and storing that number of 10-gallon cans of milk per day, table 3 was prepared. It is based on average efficiencies of equipment and on the actual sizes of motors used to cool such tanks over the central, southern, and eastern parts of the United States.

SIZE OF STORAGE TANK OR BOX

Table 4 is based on average efficiencies and gives the approximate sizes of refrigerating units, motors and brine tanks to cool different quantities of milk through a 60° temperature range and to cool the proper size of box to store it at an average box temperature of 40° F. The average daily temperature of the air surrounding the box was taken as 85° F. This is considered the maximum temperature that need be used. Greater temperatures that may be encountered in a few localities will be taken care of by a small increase in running time. If well or spring water is used to pre-cool the milk the running time of the compressor will be reduced, and in boxes designed for 300 quarts or more this reduction may be large enough to require the use of the next smaller size of refrigerating unit. Where cool soft water is available units with water-cooled condensers are more efficient than those with air-cooled condensers when the average air temperatures are high. Water that forms much scale in boilers makes it necessary to clean the condenser coils at regular intervals and the inconvenience thus caused overcomes the advantages of water-cooled condensers.

It is important that the storage tank or box be of the proper size for the amount of milk to be handled. A good general rule is to buy a size sufficient to care for the maximum daily quantity of milk produced at any season of the year, and no larger. The economy of this practice is shown by table 5 where the power requirements to maintain the temperature in an eight-can storage tank alone and with different cooling loads is given.

The correct size for the storage tank depends on the method of handling the milk. In some localities the morning's milk does not have to be cooled if it is delivered to the country receiving station by a certain time. Where the morning's milk is cooled the evening's milk is sometimes set out of the cooling tank and stands on the milk room floor until the morning's milk has been cooled and both lots are loaded. This practice may lower the quality of milk and where there is a long haul the milk temperature may go above market requirements. Another practice is to cool and store the evening's milk and to cool the morning's milk over a milk cooler only. This is a good method where proper sanitation is observed and local milk regulations do not prohibit the use of such equipment.

TABLE 3.—*Approximate capacity of compressor and size of electric motor*[1] *necessary to cool and store different quantities of milk a given number of degrees of temperature, if the motor runs 12 hours a day*

Range of cooling temperature (° F.)	Compressor capacity and motor size for the indicated sizes of tank														
	4-can			6-can			8-can			10-can			12-can		
	M. i. e.[2] rating		Approximate motor size	M. i. e. rating		Approximate motor size	M. i. e. rating		Approximate motor size	M. i. e. rating		Approximate motor size	M. i. e. rating		Approximate motor size
	Per hour	Per day		Per hour	Per day		Per hour	Per day		Per hour	Per day		Per hour	Per day	
	Lbs.	*Lbs.*	*Hp.*	*Lbs.*	*Lbs.*	*Hp.*	*Lbs.*	*Lbs.*	*Hp.*	*Lbs.*	*Lbs.*	*Hp.*	*Lbs.*	*Lbs.*	*Hp.*
10	2.8	67	¼	4.2	101	⅓	5.6	134	½	7.0	168	½	8.4	202	½
20	5.2	125	¼	7.8	187	⅓	10.4	250	½	13.0	312	½	15.6	374	½
30	8.0	192	⅓	12.0	288	⅓	16.0	384	½	20.0	480	½	24.0	576	¾
40	10.8	259	⅓	16.2	389	⅓	21.6	518	½	27.0	648	¾	32.4	778	¾
50	13.6	326	⅓	20.4	490	½	27.2	653	¾	34.0	816	¾	40.8	979	1
60	16.0	348	½	24.0	576	¾	32.0	768	¾	40.0	960	1	48.0	1,152	1
Approximate[3] length of ½-inch copper tubing for coil	*Feet* 40–60			*Feet* 50–70			*Feet* 60–80			*Feet* 70–90			*Feet* 80–100		

[1] Gasoline motors are not so efficient as electric motors nor are they made in as small sizes. Most compressors of the sizes given in this table are driven by 1½- or 2-horsepower gasoline motors.

[2] M. i. e. = melting-ice equivalent.

[3] The length of cooling coils needed depends on many factors, such as the refrigerant, its operating temperature and pressure, and the temperature desired in the storage medium. The manufacturer's recommendation for length of coils should be obtained. See p. 14.

TABLE 4.—*Size of storage boxes, their equipment and operation necessary to cool milk 60° F. and store it in bottles if the average storage temperature is 40°, the air temperature is 85°, and the coefficient of heat transfer through the walls of the box is 2 B. t. u. per square foot per degree temperature difference per 24 hours*

Capacity of box	quarts	200	300	400
Size of refrigerated space	feet	3 x 4 x 6	4 x 6 x 7	6 x 6½ x 7
Size of brine tank required	do	2 x 3 x 2½	3 x 1½ x 5	5 x 1¾ x 4
Brine required	gallons	107	161	222
Vertical tank surface required[1]	square feet	25	41	53
Size of compressor	m. i. e.,[2] pounds per hour	22	42	61
Size of motor	horsepower	½	1	1½
Operating time	hours	13	11	10

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[1] When the vertical tank surface is less than required, vertical fins must be added to the tank.
[2] See footnote 2, table 3.

TABLE 5.—*Approximate power requirements per day for an 8-can storage-tank outfit when used for cooling and storing different quantities of milk*[1]

Item	To keep tank cool	To cool—				
		4 cans; store 2 cans	8 cans; store 4 cans	10 cans; store 5 cans	12 cans; store 6 cans	16 cans; store 8 cans
	Watt-hours	*Watt-hours*	*Watt-hours*	*Watt-hours*	*Watt-hours*	*Watt-hours*
Total	3, 627	5, 719	7, 811	8, 857	9, 903	11, 995
Per can	------------	1, 430	976	886	825	750

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[1] These figures are based on an average outside temperature of 80° F. and an average storage-tank temperature of 40°. An analysis of the data used in arriving at these figures is given in Circular 336, Cooling Milk on the Farm With Small Mechanical Outfits.

Where both night's and morning's milk are placed in the cooling tank or when milk production varies, the cooling tank is sometimes divided into two sections by a dividing wall as high as the desired water level. A pump is used to circulate the water from one section to the other. After one division has been pumped full, the water overflows the dividing wall and goes back into the compartment having the lower water level. This system not only keeps the water level constant around the cans but also provides for circulating the water and thus cooling the milk more quickly.

LOCATION OF THE BRINE TANK IN STORAGE BOX

A number of the outfits studied had dry-storage boxes. When this type of storage is used with a refrigerating machine on the dairy farm, the most advantageous location of the brine container or tank is at the top of the storage box (fig. 10). Either copper, galvanized iron, or boiler plate may be used for constructing the brine tank; the last is probably the cheapest. If boiler plate is used, apply a protective coat of red lead. If the evaporating coils are of copper, a copper tank is probably more satisfactory, as having only the one kind of metal eliminates electrolysis, which causes corrosion.

The brine can be made either of sodium chloride (common salt) or calcium chloride. The latter is generally used, as it has a lower freezing temperature with the same concentration. The quantity of brine required in the tank depends on the quantity of milk to be cooled daily, the desired cooling temperature, and the size and insulation of the box. However, as a general rule, with calcium chloride brine, there should be about 1½ to 2 gallons of brine in the tank per gallon of milk cooled per 24 hours. In making up the brine, 2½ pounds of calcium chloride, with 1 ounce of lime for preventing electrolysis, should be added to each gallon of water. The average temperature of the brine usually used on dairy farms is 20° to 25° F.

Where gasoline motors are to be used, allowance must be made for differences in the sizes of available motors and their efficiency. Since gasoline-motor-driven units are, as a rule, not automatic in operation, the unit is run only twice a day for from 2 to 8 hours at milking times. For this reason the compressor is often larger than those used to do the same work when driven by electric motors.

THERMOSTATIC CONTROL IN THE STORAGE

To maintain a nearly constant temperature in the storage tank or box, electrically operated machines are generally equipped with a thermostatic control. This device starts and stops the machine automatically whenever the temperature in the box or tank varies a few degrees above or below the desired temperature.

In a dry box such controls can be located at a height where they will be protected from mechanical injury. Except in very large units the temperature at the ceiling in a well-constructed dry box should not be more than 2° or 3° higher than at the floor. Such a small difference can be taken care of by the setting of the thermostat. For instance, if it is necessary to place the control near the top of the box to protect it from mechanical damage and a temperature of 33° is desired at the average storage height, the thermostat can be set at about 35°.

A mechanical unit to cool a dry storage box for handling bottled milk should have enough capacity to cool the bottles and crates as well as the milk. The average cooling load for bottles and crates alone with the milk-room temperature at 80° F. is approximately 1.4 pounds of melting-ice equivalent for each gallon of milk. The following example shows how to figure the cooling load on a farm where 100 gallons of milk a day are cooled and bottled if the milk is cooled to 40° by refrigeration and the milk-room temperature is about 80° F.

The refrigeration required per day per 10-gallon can is 32 pounds of melting-ice equivalent (table 2). Then 10 multiplied by 32 gives 320 pounds to cool and store 100 gallons. The cooling load for bottles and crates would be 100×1.4, or 140 pounds of melting-ice equivalent. The total load would be 320 plus 140, or 460 pounds of melting-ice equivalent. Since this refrigeration should be furnished in about 12 hours the capacity of the compressing unit should be 38.33 pounds of melting-ice equivalent per hour (460 pounds divided by 12) or 920 pounds of melting-ice equivalent per day (24×38.33).

In wet tanks equipped with some means of agitation the thermostatic-control bulb can be located at almost any point along the refrigeration coils since the temperature varies little throughout the tank. The bulb must be covered with water at all times. If tank water is pumped through a milk cooler, agitation of the water in the tank will be unnecessary. The milk will be cooled quickly below 50° F. before being placed in the tank and the circulation of the storage water through the cooler will give some agitation in the tank. A test of arrangements of cooler intake and outlet shows that the intake should be as far as possible from the thermostatic control and the cooler outlet over the control. Where there is a tendency for too much ice to freeze on the coils the cooler return can be extended along the coils with a length of pipe having a row of small holes in its unde side to distribute the warm water over the coils.

AGITATION OF WATER IN STORAGE TANKS

Where milk is strained directly into cans and placed in the tank t be cooled from near body temperature to below 50° F. the wate should be agitated. The movement of the water not only keeps it temperature almost even throughout but also removes the heat from the milk in a shorter time. Tests show that the temperature of al the milk in a 10-gallon can will be reduced to 50° or below in 1 hou or less if the water is thoroughly agitated, sufficient refrigeration i supplied, and a milk to water ratio of 1 to 1⅜ or more is used. Without agitation it may require 7 or 8 hours, depending on the initia water temperature, the refrigeration available, and the water to mil ratio. The water can be moved in several ways. In some cases a propeller is mounted on the end of a shaft and connected to a vertica motor placed on top the cooling tank (fig. 4). In other tanks the water is pumped from one storage compartment into another or from the coil compartment to the storage space. It may likewise be pumped from the bottom of the tank through a pipe placed around the top of the tank with a narrow slit or perforated openings so located as to spray cold water over the milk cans. Another method now employed is to use a small pump to force air through the water.

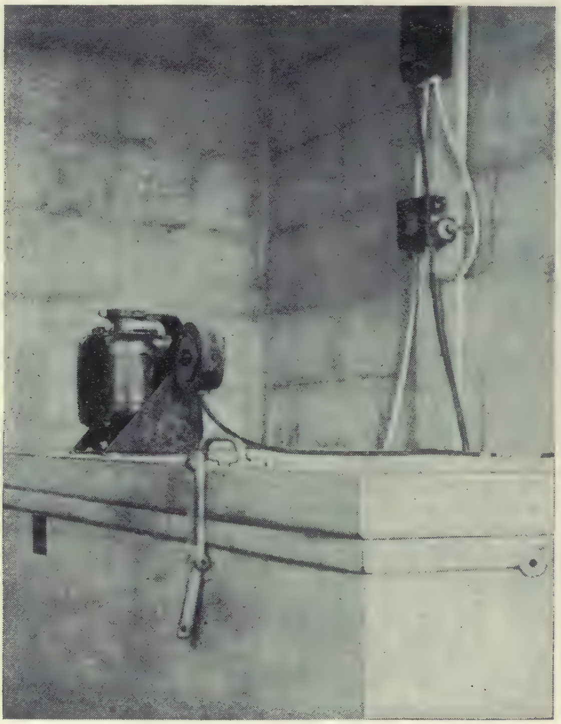


FIGURE 4.—A vertical electric motor on a storage tank for driving an agitator.

The air pump's intake is placed just above the water level in the tank, and its outlet is connected to perforated pipes laid along the sides of the tank. A good way to equip a home-made tank for agitation is to set up a small centrifugal pump with its intake at the bottom of the tank and its outlet at the top at the opposite end.

COILS IN STORAGE TANKS

In wet-storage tanks three systems of installing coils are used: (1) Bunched coils, made of pipe or tubing, placed in the center of the tank or along a side or end or in a corner and separated from the storage space by a baffle plate, an iron rail, or a grill (fig. 5); (2) coils made of pipe, tubing, or cast-iron heating radiator sections (figs. 6 and 9) arranged around the inside wall of the tank; and (3) coils made of pipe placed on the bottom of the tank. Bunched coils are sometimes difficult to support adequately, and they must be protected against being struck with the cans of milk. Also, ice accumulates more readily on bunched coils than on coils of other types, because the coils are closer to each other and generally farther from the return water of the circulating pump. Accumulations of ice as thick as shown in figure 5 are undesirable in tanks without some means of circulating the water. Where coils are placed on the bottom or around the inside walls of the tank, they should be adequately protected by a frame.

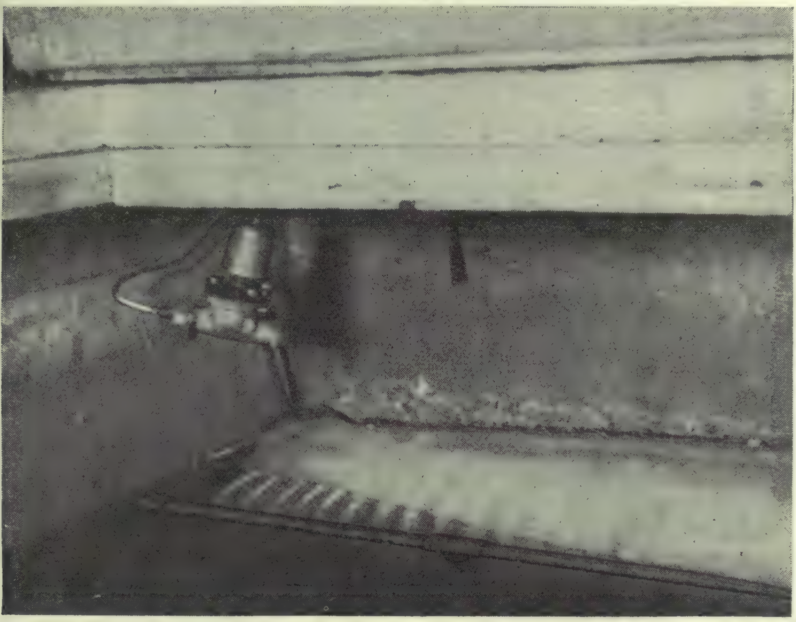


FIGURE 5.—A spiral refrigerating coil placed along one side of a tank and guarded by a pipe rail. Note the accumulation of ice on the coil.

In the tanks observed the coils were almost all made of tubing of ½-inch inside diameter. The length of coil used per cubic foot of tank space differed greatly, and the figures given in table 3 are approximate. The proper length of cooling coil depends primarily on the design of the compressor, its operating pressures, and the refrigerant used, although it is also influenced by the temperature range through which the milk is cooled and whether the tank water is still or agitated. Since the compressor and the coils are part of the manufactured unit, the recommendation of the manufacturer for length of coils should ordinarily be accepted.

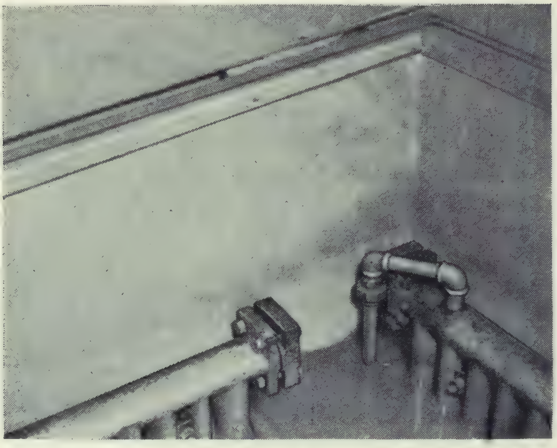


FIGURE 6.—Refrigerating coils assembled from cast-iron heating radiator sections, arranged around the inside wall of the storage tank. Copper tubing is generally used for coils.

Farmers writing to manufacturers for information regarding the selection of the proper size of refrigerating unit should give the following data: The maximum quantity of milk to be cooled and stored per 24 hours at any season; the range of temperature through which the milk is cooled (for example, from 95° to 40° F.); the temperature of the well water if well water is used; and the thickness and kind of insulation in the tank.

CARE OF STORAGE WATER

The water in tanks must be kept clean and free from objectionable odors. The care used to keep the water clean governs the length of time between changes of water. On the farms observed, the frequency of changing water in the storage tanks ranged from once a week to once in 5 months, and the length of time needed to bring the tank back to its normal storage temperature ranged from 4 to 24 hours. Where the interval between changes was 5 months, extreme care was used in cleaning the outside of the cans just before they were placed in the tank. There is a decided saving in keeping the cans clean since every time the tank water is changed the refrigerating unit must operate extra time. Where the cooling machine is working nearly at capacity, or the temperature of the clean water is high, changing water may result in inadequate cooling and storage of the milk at the next milking.

FACTORS AFFECTING THE OPERATION OF THE MACHINES

Several factors affect the reliable and efficient operation of a mechanical-cooling unit. One of the most important of these is the number of hours the compressor must operate each day to extract the necessary amount of heat from the milk through the cooling tank. If a machine runs practically all the time it may not use any more power than one running only 10 or 12 hours a day, but it will have no reserve refrigerating capacity to care for any additional milk or a spell of extremely hot weather, and a power failure or mechanical break-down even of short duration would make proper cooling impossible. If the machine is so small as to require almost continuous operation, its capacity would not be sufficient to cool the milk to below 50° F. in 1 hour unless the water to milk ratio is very high or comparatively large quantities of ice are frozen on the coils. It must be remembered that when ice surrounds the coils it acts as insulation; a large accumulation is therefore undesirable when the tank is not equipped with some means of mechanical agitation. According to tests conducted on dairy farms, described in Circular 336, under farm operating conditions the cost of cooling milk when the refrigerating unit ran from 8 to 10 hours a day was less than when it ran 14 hours or more. Then, too, small refrigerating machines are not designed for continuous operation, and the life of an overworked machine is comparatively short.

For economical cooling, the storage tank or box must be well insulated with waterproofed insulation. The general practice now is to equip tanks with 3 inches of insulation and dry boxes with 3 or 4 inches. Many home-made tanks and boxes have been equipped with 4 or 5 inches of insulation. In sections where high average daily temperatures are expected, an extra inch of insulation will more than pay for itself. In tests conducted by the Department it was found that home-made tanks were as efficient as manufactured tanks. However, all the home-made tanks contained 1 inch more of insulation than the commercial tanks.

As stated on page 7, the refrigeration loss from a well-constructed tank or box used to capacity should not be more than 30 percent. This figure includes not only the heat leakage through the walls but also losses due to handling the milk in and out of the storage. When a milk cooler is used the same figures will apply.

Precooling milk over a cooler has the advantage of lowering the temperature of the milk quickly below 50° F., and where cold well or spring water is used through part or all of the cooler such precooling reduces the refrigeration load and consequently the cost of cooling. The amount of heat that can be removed by running the milk over a cooler depends on the temperature of the cooling medium run through the cooler coils, the amount per minute, and the speed at which the milk flows over the cooler. The difference between the temperature of the cooling medium and the milk after the cooling operation was found to vary from about 1° to 10° F., and averaged 3°. If 60° water is run through the coils of a milk cooler and the milk is allowed to pass over its surface in a thin solid stream it would be cooled to about 63°. Thus if the milk is to be cooled to 40° it would be necessary to lower its temperature 23° additional by refrigeration.

Milk coolers can be piped to use well or spring water alone, well or spring water through the top half and tank water or brine through the lower half (fig. 7), and tank water or brine through the entire cooler (fig. 8). The method used depends on the way the milk is handled and the availability of water. If water is scarce or has to be pumped against a high head it may be least expensive to pump tank water or brine through a cooler. Where the morning's milk is to be shipped without any storage it is necessary to use tank water or brine through half or all the cooler to reduce the temperature of the milk sufficiently to have it reach the market in good condition. Regardless of what cooling medium is used, the cooler should be piped so that the cold medium enters the bottom of the cooler and leaves the top. This insures that the milk will pass over the coldest part of the cooler last and gives the greatest amount of cooling. The tap water used in the top half of the cooler shown in figure 7 leaves the top of the cooler through a short piece of hose and is wasted on the floor.

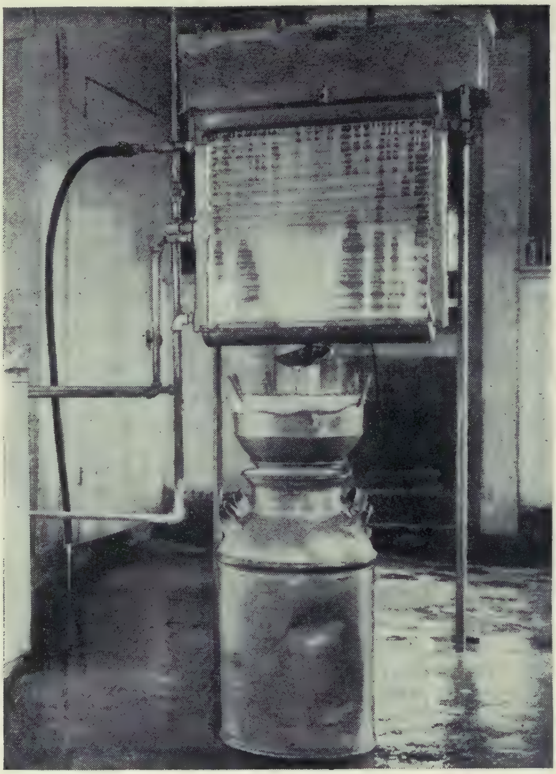


FIGURE 7.—Milk cooler piped to run tap water through the top half and tank water through the bottom half.

Dry-box storage has been found to require more power per gallon cooled than wet-tank storage and is seldom used to cool bulk milk. It is satisfactory for such use only when the milk is first cooled over a milk cooler. One big advantage of this system is that because of the use of a brine or direct-expansion milk cooler the milk can be cooled to a lower temperature in a shorter time.

PLANS FOR STORAGE TANK AND BOX

The drawings shown in figure 9 give detailed plans for the construction of an insulated concrete storage tank with an insulated wood cover. Several different kinds of insulation, loose or in waterproof packages, may be used. Corkboard has been the most popular. Regardless of the insulation used, it must be covered thoroughly with asphalt to keep out moisture. The insulating value of any material is greatly decreased if it becomes wet. The bottom of the tank may be made smooth instead of ridged as shown, but in that case the cans should be set on a grating made of water-resisting wood or a sheet of galvanized corrugated metal, to permit the circulation of water under the cans. The number and size of the coils and the size of the compressor unit depend on the maximum quantity of milk to be cooled daily and the number of degrees through which the milk is to be cooled (table 4).

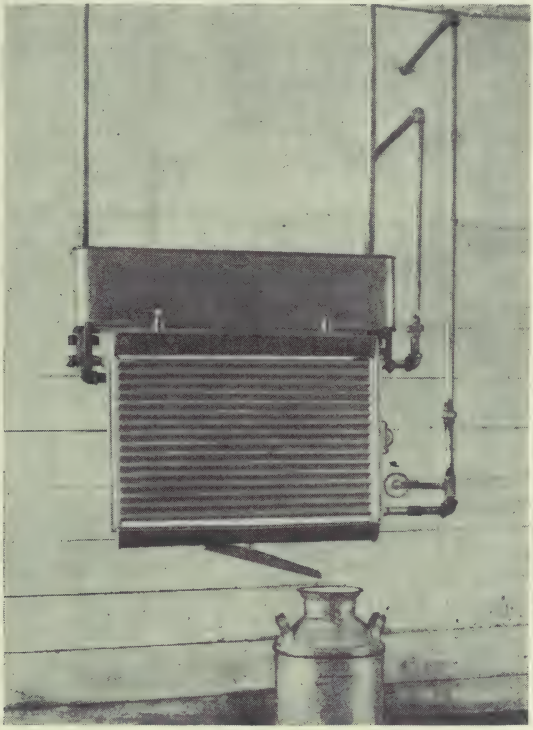
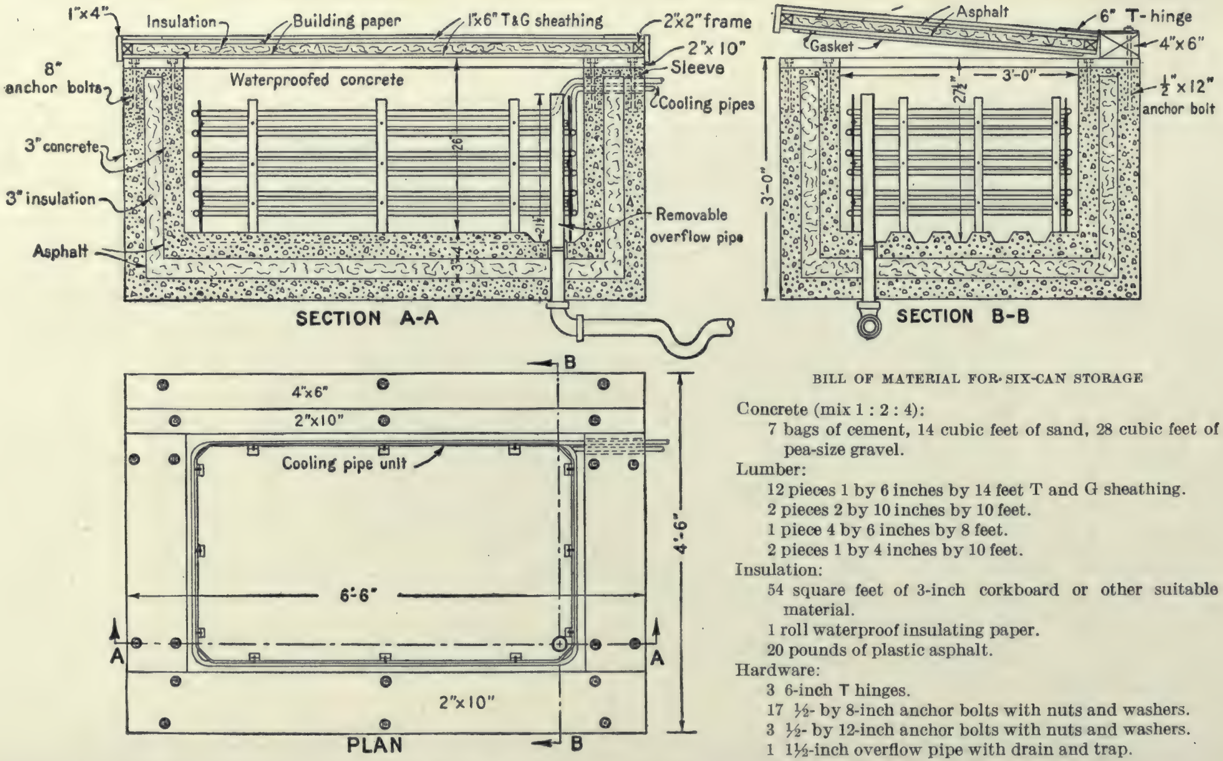


FIGURE 8.—Milk cooler piped to run brine through the entire cooler.

The small dry box shown in figure 10 has been designed primarily for use on farms where the milk is bottled. If the milk is to be stored in cans, the box will take care of a much larger quantity of milk than if it were stored in bottles, and care should be taken to have a compressor and a brine tank large enough to supply the total amount of refrigeration in 10 or 12 hours and to cool the milk to the desired storage temperature in the time that it is allowed to run over the surface cooler.


1"x4"
Insulation
Building paper
1"x6" T&G sheathing
2"x2" frame
2"x 10"
Sleeve
Cooling pipes
8" anchor bolts
Waterproofed concrete
3" concrete
3" insulation
Asphalt
Removable overflow pipe
26"
SECTION A-A
Asphalt
6" T-hinge
Gasket
4"x6"
½"x12" anchor bolt
3'-0"
27½"
3'-0"
SECTION B-B
B
4"x6"
2"x10"
Cooling pipe unit
4'-6"
6'-6"
A
A
2"x10"
PLAN
B

BILL OF MATERIAL FOR SIX-CAN STORAGE

Concrete (mix 1 : 2 : 4):
  - 7 bags of cement, 14 cubic feet of sand, 28 cubic feet of pea-size gravel.

Lumber:
  - 12 pieces 1 by 6 inches by 14 feet T and G sheathing.
  - 2 pieces 2 by 10 inches by 10 feet.
  - 1 piece 4 by 6 inches by 8 feet.
  - 2 pieces 1 by 4 inches by 10 feet.

Insulation:
  - 54 square feet of 3-inch corkboard or other suitable material.
  - 1 roll waterproof insulating paper.
  - 20 pounds of plastic asphalt.

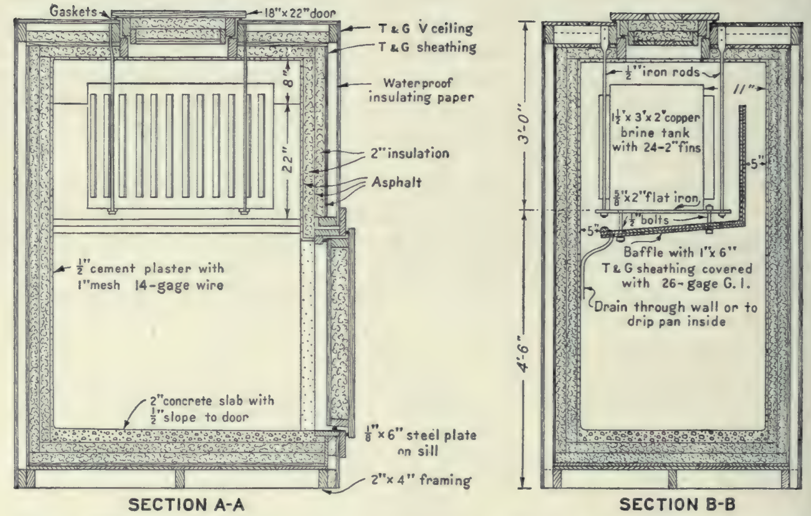
Hardware:
  - 3 6-inch T hinges.
  - 17 ½- by 8-inch anchor bolts with nuts and washers.
  - 3 ½- by 12-inch anchor bolts with nuts and washers.
  - 1 1½-inch overflow pipe with drain and trap.

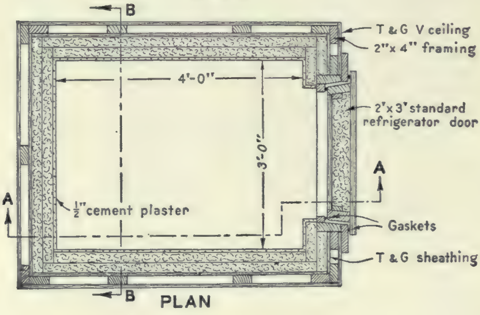
FIGURE 9.—Plan for constructing a storage tank.

Dry-box storage is not recommended for cooling milk. It is used nly as a low-temperature storage place for the milk which has been reviously cooled.

Figure 11 shows a plan for a walk-in storage box, and gives an lternate design of wall construction to be used with fill insulation. Fill nsulation is generally available in many forms, may cost less, and s as efficient as rigid insulation when properly installed. However, reat care must be exercised in applying the waterproof insulating aper outside the fill to form a complete vapor seal. The paper nould be folded into corners where feasible rather than being cut-in. n the case of doorways where cutting is imperative the joints should e covered with an extra layer of paper after being coated with asphalt. ince the efficiency of the insulation is lowered by the absorption of noisture, this care is necessary to keep the warm moisture-laden air rom seeping into the fill compartment, where it is chilled by the cold all next the refrigerated room and some of its moisture is deposited n the insulation.

The drawings show the inside walls of the box finished with cement laster. If desired, wood sheathing may be placed inside of the nsulation and covered with 26-gage galvanized iron. All joints nust be soldered. A direct-expansion coil can be substituted for the rine tank in the storage box, if a direct-expansion milk cooler is to e used.


Gaskets
18"×22" door
T & G V ceiling
T & G sheathing
Waterproof insulating paper
8"
22"
2" insulation
Asphalt
½" cement plaster with 1" mesh 14-gage wire
2" concrete slab with ½" slope to door
⅛"×6" steel plate on sill
2"×4" framing
SECTION A-A
3'-0"
4'-6"
½" iron rods
11"
1½'×3'×2' copper brine tank with 24-2" fins
5"
⅝"×2" flat iron
½" bolts
5"
Baffle with 1"×6" T & G sheathing covered with 26-gage G. I.
Drain through wall or to drip pan inside
SECTION B-B


B
T & G V ceiling
2"×4" framing
4'-0"
3'-0"
2'×3' standard refrigerator door
A
A
½" cement plaster
Gaskets
T & G sheathing
B
PLAN

BILL OF MATERIAL FOR STORAGE OF 50 GALLONS IN QUART BOTTLES

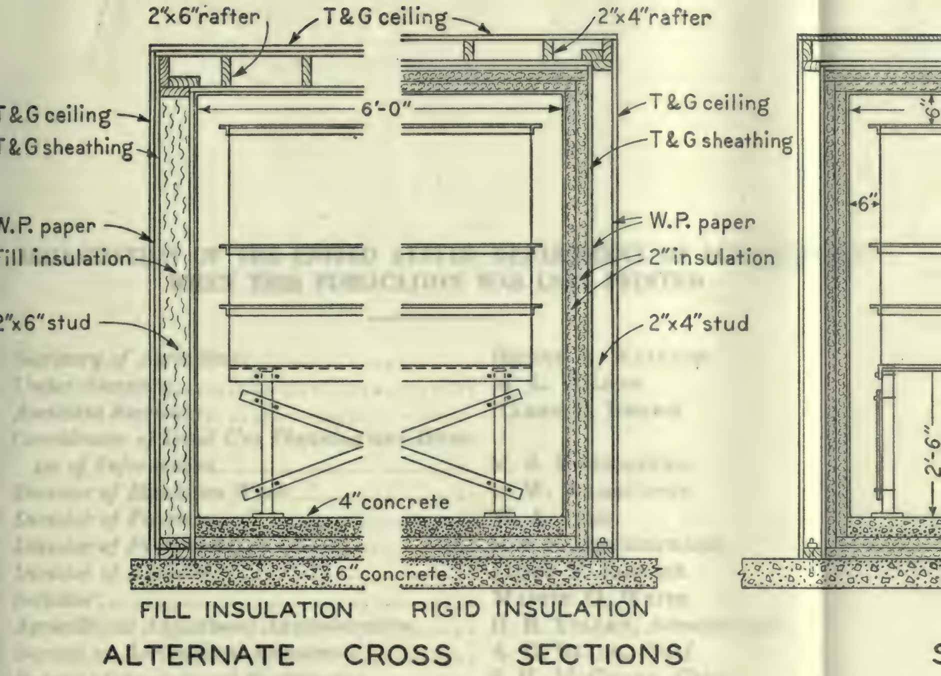
Concrete (mix 1 : 1½ : 3)
- 1 bag cement, 1½ cubic feet sand, 3 cubic feet gravel.

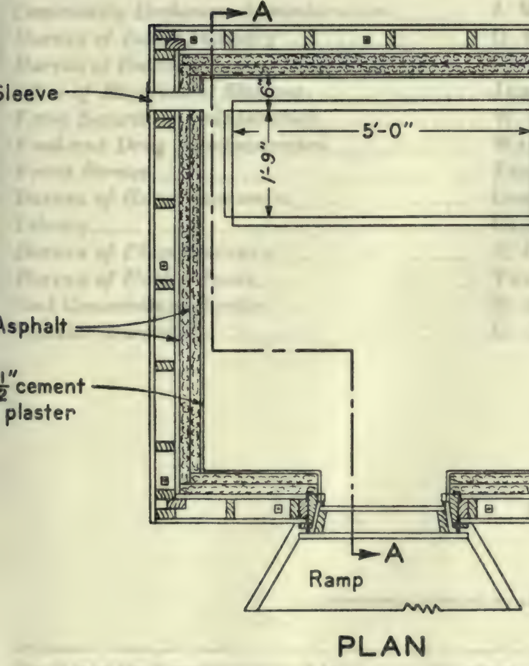
Plaster:
- 3 bags cement, 4 cubic feet sand.

Lumber:
- 250 board feet, 1- by 6-inch T. and G. sheathing.
- 200 board feet, tongue-and-groove V-ceiling.
- 15 pieces 2 by 4 inches by 8 feet.
- 15 pieces 2 by 4 inches by 10 feet.

Miscellaneous:
- 50 pounds of plastic asphalt.
- 250 square feet of 2-inch corkboard or other suitable insulating material.
- 2 rolls waterproof insulating paper.
- 1 2- by 3-foot standard refrigerator door and equipment.
- 4½- by 40-inch iron rods, threaded on one end.
- 2½- by 8-inch machine bolts, with nuts and washers.
- 4⅝- by 2-inch iron flats, 26 inches long.
- 20 square feet 26-gage galvanized iron.
- 1¾-inch drain pipe, length as required.

FIGURE 10.—Plans for constructing a storage box.


2"×6"rafter
T&G ceiling
2"×4"rafter
T&G ceiling
T&G sheathing
W.P. paper
Fill insulation
2"×6"stud
6'-0"
T&G ceiling
T&G sheathing
W.P. paper
2"insulation
2"×4"stud
4"concrete
6"concrete
FILL INSULATION
RIGID INSULATION
ALTERNATE CROSS SECTIONS
6"
6"
2'-6"
S


A
Sleeve
6"
5'-0"
1'-9"
Asphalt
½"cement plaster
A
Ramp
PLAN

BILL OF MA
BOX FOR 4
INSULATEI

Concrete (mix 1
5 bags cemen
Plaster:
7 bags cemen
Lumber:
450 board fee
400 board fee
55 pieces 2 b
Miscellaneous:
100 pounds p
675 square fe
sulation.
4 rolls water
1 2- by 6-foo
equipment
4 pieces 2-inc
4 6-inch floor
14 feet 3- by
12 feet ½- by
12 ⅜-inch U
1 5-foot by 1
9 ½- by 6-inc

FIGURE 11.—Plans for walk-in storage box

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U. S. DEPARTMENT OF
AGRICULTURE
FARMERS' BULLETIN No. 1819

INFECTIOUS ANEMIA
(SWAMP FEVER)

INFECTIOUS ANEMIA is widely distributed and results in serious loss of horse and mule power in certain regions of the United States. There are also some losses through death. The disease is prevalent in many foreign countries as well as in this country.

Although this disease is known extensively as swamp fever, this name is not desirable as it is used also for malarial fever, a human disease caused by a parasite. Infectious anemia is caused by a virus which is present in the blood, body tissue, and body secretions of affected animals. Transmission of the infection from affected to healthy animals is believed to result from contaminated pastures or from biting insects which have fed on affected animals.

There are two principal forms of the disease. The chronic form is most common and is characterized by intermittent fever, loss of weight and strength, marked depression, and swellings on the under surface of the body and on the legs. The disease may appear also in the acute form, which is rapidly fatal. Still another or latent form produces no clinical symptoms, but the animal is a carrier of the infection.

There is no preventive vaccine known to be of value for infectious anemia; neither is there any treatment that will cure the disease. However, the usefulness of an affected animal can be prolonged by supportive treatment prescribed by a veterinarian. The available means of controlling this disease consist in protection against biting insects and preventing the infection from reaching healthy animals through contaminated feed and water. In areas where the disease is prevalent, its ravages can be held to a minimum by attending to sanitary conditions, furnishing abundance of feed, controlling parasites, and eliminating any factors that might exert a debilitating influence on the animals.

Washington, D. C. Issued December 1938

INFECTIOUS ANEMIA (Swamp Fever)

By **William S. Gochenour**,[1] *senior veterinarian*, **Clarence D. Stein**, *associate veterinarian*, and **Oswald L. Osteen**, *junior veterinarian*, *Pathological Division, Bureau of Animal Industry*

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DISTRIBUTION AND PREVALENCE

INFECTIOUS ANEMIA, or swamp fever, is a specific, infectious disease that has long been recognized, having been reported from Europe as early as 1843. It has a wide geographical distribution, occurring in various parts of Europe, South Africa, Japan, Canada, and the United States. The disease has been authentically reported from the following 24 States: Arkansas, Colorado, Florida, Idaho, Illinois, Indiana, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New York, North Dakota, Oregon, Tennessee, Texas, Utah, Virginia, Wisconsin, and Wyoming. Infectious anemia is of considerable economic importance in the Mississippi Delta where the disease has become established among the mules on the large cotton plantations. In this area the disease exists principally in the chronic form, saps the strength of the animals, and renders them incapable of regular work in the busy, cotton-growing season when they are most needed.

The disease is probably more widespread than the reports indicate. Doubtless it has not been recognized because of the difficulty of diagnosing the chronic and inapparent forms of the disease. In the inapparent form, there are no clinical symptoms, and the animal appears normal and eats in a normal manner, yet continuously harbors infection. Generally speaking, infectious anemia is most prevalent in poorly drained, low-lying sections, but it has been found at altitudes as high as 7,500 feet. The disease appears to be more prevalent when biting insects are most numerous; and during wet years more than in dry seasons. The active form of the disease makes its appearance in May or June, reaches its height in midsummer, and declines late in the fall. Chronic cases may be seen in the winter, and it is possible to produce the disease experimentally at any time.

---

[1] Resigned, October 1938.

CAUSE

Infectious anemia is caused by an infectious agent known as a filtrable virus. In the lower animals the disease occurs in the horse, mule, and ass only. Infection in man has been reported in several instances, but it is probable that man is not very susceptible to the disease. The infectious agent is apparently present in the blood and body tissues of affected animals at all times and may be eliminated with any of the secretions and excretions. The disease can be readily transmitted experimentally to equines (horses, mules, and asses) by inoculation beneath the skin or into the blood stream, of whole blood, blood serum, spleen, brain, or other tissue emulsions. The infectious agent passes through diatomaceous-earth filters that will remove all visible or cultivatable forms of organismal life, such as bacteria, trypanosomes, and piroplasmata.

Transmission from diseased to healthy animals has been accomplished experimentally with the stable fly (*Stomoxys calcitrans*) and other insects. In a recent experiment conducted by the Bureau of Animal Industry the disease was transmitted by intimate stable contact in which the animals intermingled unrestrained in a large stable, drank from a common watering trough, and fed from the floor. In this experiment insects were controlled by tight screening of all windows and doors, and the entrance to the building was equipped with a double-compartment, screened vestibule. In the experience of the Bureau's investigators the disease did not spread from infected to normal animals when they were kept in adjacent stalls or adjoining box stalls, and water and feed were supplied from individual containers. Definite information is lacking, however, concerning the mechanism of infection in the natural state. Some investigators believe that the disease is spread principally while the animals are at pasture where the virus-laden urine and feces of an infected animal contaminate the feed and water of the healthy animals, but the part that biting insects play while animals are at pasture cannot be ignored.

FORMS

Infectious anemia may occur as an acute, rapidly fatal disease, or what is more common, as a chronic affection characterized by intermittent attacks of fever, loss of weight, progressive weakness, marked depression, and dropsical swellings on the lower portions of the body and on the legs. The disease may also exist in a form in which no clinical symptoms are observed, yet the animal so affected carries virulent virus in the blood stream at all times.

In the acute form of the disease, the incubation period following the subcutaneous injection of infected blood is usually about 12 to 15 days. However, it may vary from less than a week to 3 months and possibly longer. The onset is sudden and is manifested by a rise in temperature which usually reaches about 105° F. but may reach 108°. Respiration is accelerated and frequently is of the abdominal type. The animal is dejected, the head hangs low, leg weakness is marked (fig. 1), the body weight is shifted from one leg to another, and the hind feet are frequently placed well forward under the body. The membranes of the eye show congestion, followed by brownish to yellowish discoloration. Feed is refused. The attack usually lasts from 3 to 5 days, after which the temperature returns to normal, and the animal appears to be well, except for a marked loss of weight.

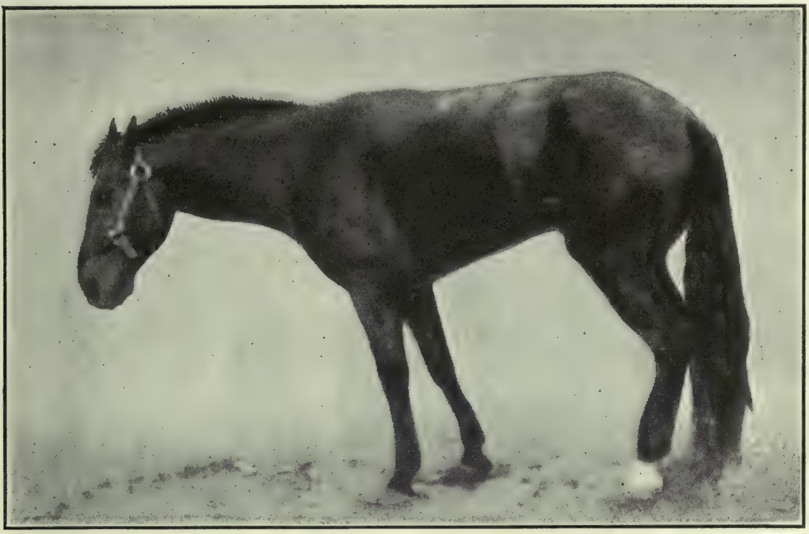

FIGURE 1.—Horse affected with the acute form of infectious anemia, showing extreme weakness of hind quarters.

Occasionally, however, the initial attack may persist until the animal dies. Dropsical swellings of the sheath, the legs, the breast, and under surfaces of the body may occur at any time (fig. 2). These frequently disappear and appear again at the same or other places. Subsequent attacks usually follow, with intervening periods of normalcy varying from a few days to many weeks or months. When the intervals between the attacks of fever are short the animal seldom lives more than 15 to 30 days. During the attacks of fever and immediately afterward, there is a destruction of red blood corpuscles, usually 1 to 1½ million per cubic millimeter. The red-corpuscle count in exceptional cases has been noted to fall to 3 or 4 million per cubic millimeter. When the reduction of red corpuscles is pronounced, it can be readily demonstrated by drawing blood into a test tube in the bottom of which a small amount of powdered potassium oxalate or other anticoagulant has been placed to prevent clotting. A little agitation of the test tube during the drawing of the blood and immediately afterward in the presence of the anticoagulant will prevent clotting and permit the red corpuscles to gravitate to the bottom of the tube. A comparison of the sedimented red corpuscles with a sample similarly drawn from a normal horse will clearly demonstrate the degree of anemia that exists. In addition the supernatant serum will occasionally exhibit a greenish hue. During the periods of normalcy, between the attacks, the red-corpuscle count is in a great majority of cases normal.

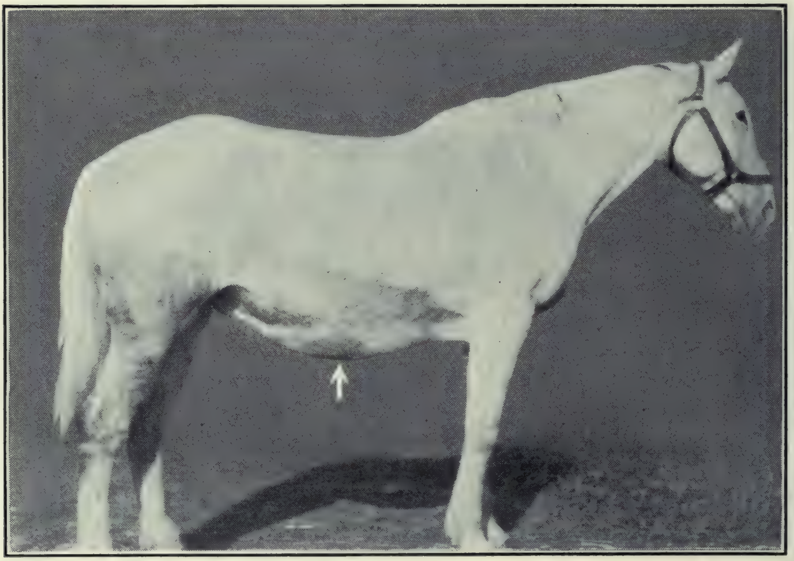

FIGURE 2.—A case of the subacute form of infectious anemia, showing extensive dropsical swellings (shown by arrow) on the abdomen.

The subacute and chronic forms of the disease differ from the acute in that the attacks are less severe and the intervals between the attacks are longer. It is not uncommon in the chronic form of the disease for the affected animals to remain in apparently good physical condition and to be capable of a considerable amount of work in the periods between the attacks of fever. In general, however, the chronic form of the disease is manifested by unthriftiness, rough coat, loss of weight, sluggishness, weakness, dropsical swellings of the lower parts of the body or on the legs, muddy discoloration of the visible mucous membranes and small hemorrhages on the nictitans membrane (haw) and the nasal septum. In this form of the disease the appetite is unimpaired for the most part and frequently is ravenous so that the animals may be observed to be eating continuously if they have access to feed. In spite of an excessive consumption of feed, however, there is a progressive loss of body weight (fig. 3). It is this chronic form of the disease that is most commonly seen in the Mississippi Delta, and the damage is principally one of heavy losses of mule power during the cotton-growing season, when the services of the animals are most urgently needed.

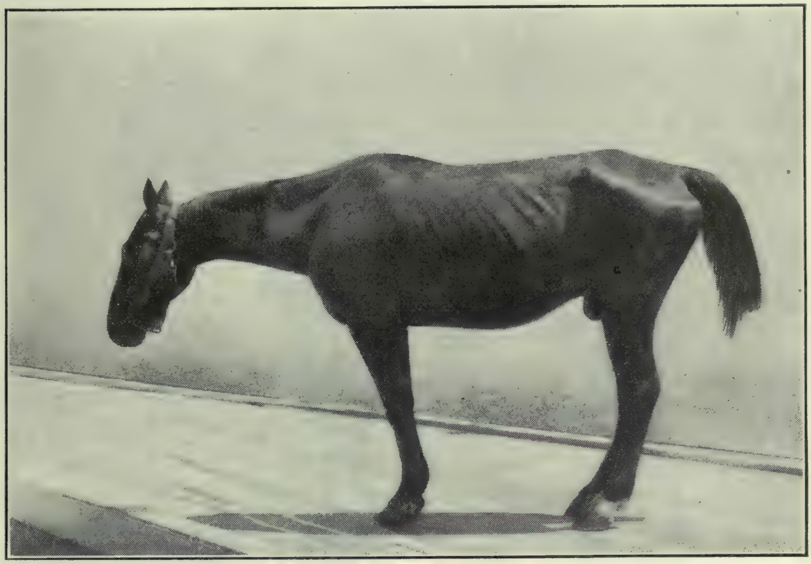

FIGURE 3.—Horse affected with infectious anemia in the chronic form. Note the poor condition resulting from infection.

Animals affected with this form of the disease can perform some work if handled with care. They are subject, however, to recurring attacks characterized by extreme weakness, knuckling, inability to walk in a straight line, and prominent hemorrhages on the nictitans membrane. The weakness may become so great that the animal cannot stand without support. With good attention, rest, and supportive treatment, the animals usually overcome these periodic attacks and may go back to their routine work. Each attack takes its toll of flesh and strength, however, and repetitions, if frequent enough, will so weaken the animals as to render them useless or finally bring about death by exhaustion. The North Dakota Agricultural Experiment Station reported a horse affected with the chronic form of swamp fever that lived for 14 years and, as 18 horse-inoculation tests showed, was infectious during the entire period.

The inactive or latent form of the disease may follow the first attack, but usually it is preceded by several attacks of fever. In this form of the disease no clinical symptoms can be observed in the affected animal. The temperature remains normal, no reduction in the red corpuscles takes place, and a complete absence of any sign of disease will extend over a period of years. Yet all the while the infectious agent is present in the blood stream and all the tissues and may be eliminated with the body excretions. Such animals obviously are dangerous and are a menace to other horses near them since they are veritable reservoirs of infection that for the most part go unrecognized and uncontrolled. The inactive form of the disease may, however, become active at any time, and present all the characteristics of the acute or subacute form of the disease. Unusually hard work or any debilitating influences may reactivate the inactive form.

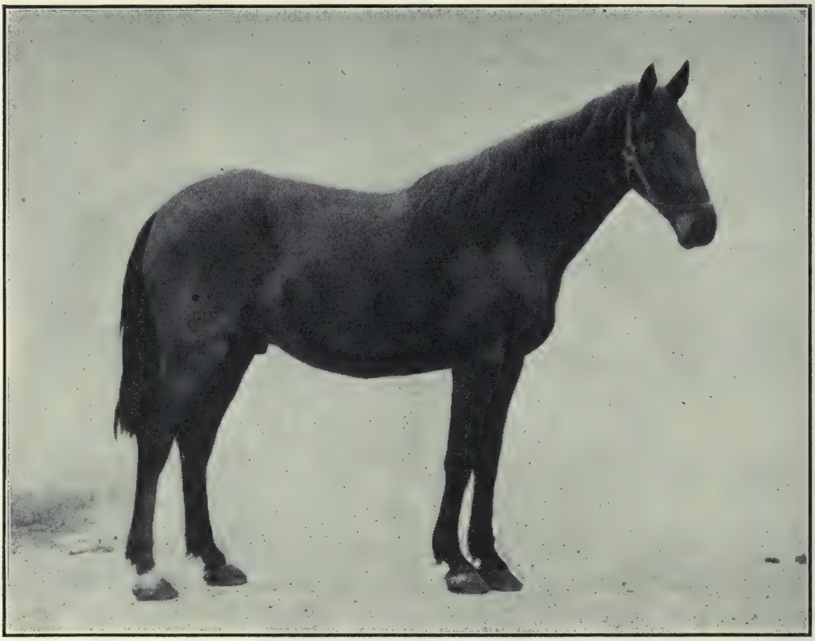

FIGURE 4.—A case of the inactive or inapparent form of infectious anemia. Although apparently in good health, this horse still carried the virus of infectious anemia, 2 years after the original infection.

The Bureau of Animal Industry had an experimental horse which was a good example of the inactive form of infectious anemia (fig. 4). This horse was exposed to the disease August 2, 1935, by being given an injection of filtered blood from two horses known to have infectious anemia. After an incubation period of 12 days, a typical attack of fever occurred, which in turn was followed by two more attacks within a 3-week period. No further attacks occurred in this horse over a period of approximately 2 years. During this time this animal remained in good physical condition and showed no symptoms of disease whatsoever. Ten normal horses were injected with blood from this animal October 4, 1935, and nine of these succumbed to infectious anemia within 31 days after inoculation, and one developed the disease in chronic form and remained alive and in good condition for 21 months, when it was destroyed. Blood drawn from the experimental horse and injected into a normal horse on December 3, 1937, produced infectious anemia in the latter, indicating the continued infectiousness of the animal suffering from the inactive form of the disease.

The Wyoming Agricultural Experiment Station reported a case of infectious anemia produced experimentally in an 18-year-old horse. This animal, although continuously infected with the disease, as proved by horse inoculation tests, lived to be 33 years old.

ANATOMICAL CHANGES

The changes in the body tissues resulting from infectious anemia are variable. They may be extremely well marked and plainly visible, or may be so slight as to escape detection by those who have not had considerable experience with the disease. For the most part the changes found in the acute cases are more extensive and more pronounced than those in the chronic cases. The most constant gross changes are hemorrhages on the serous and mucous membranes of the body, with enlargement and other changes of the spleen, kidneys, liver, and heart. The hemorrhages are most frequently found on the pericardial sac, the pleura, covering the lungs and the surface of the ribs, the peritoneum, the mucous membrane of the small and large intestines and cecum, and the surfaces of the spleen and kidneys. The spleen is frequently enlarged and soft. Occasionally it will be found to be approximately three times its normal size, and the splenic pulp will be soft and dark red. The liver is often enlarged to enormous proportions and is hard and friable. The surface sometimes presents a mottled appearance as a result of areas of degeneration that are lighter in color. Occasionally hemorrhages are seen beneath the capsule of the liver. On cross section, the lobules of the liver stand out quite prominently and the cut surface is light in color. The kidneys are frequently enlarged, watery, and lighter in color than normal and present numerous hemorrhages on the surface, ranging in size from that of a pin point to several millimeters in diameter. The heart is usually enlarged, flabby, lighter in color than normal, and may present hemorrhages on the surface, in the muscle wall, and on the inner surface of the heart muscle forming the heart cavities. The heart fat frequently loses its normal consistence and color and becomes soft and gelatinous. The visceral lymph glands may be enlarged, watery, and impregnated with hemorrhages. Large hemorrhagic areas are frequently seen in the marrow of the long bones, especially the femur. The marrow is softer than normal and in some instances becomes gelatinous. A yellowish discoloration of connective tissues and fat may also be evident. In some cases the anatomical changes are so pronounced as to make a striking picture, but, as previously stated, the lesions are quite variable and may occur in any combination.

DIAGNOSIS

Diagnosis of infectious anemia is for the most part a difficult matter since there are no symptoms or post mortem changes that can be considered characteristic and peculiar to this disease alone. The only definite means of diagnosis is by horse-inoculation test. Considering collectively the history, clinical symptoms, and blood examinations, diagnosis with a reasonable degree of accuracy can possibly be made in the active form of the disease. For example, a history of rapid loss of flesh, loss of spirit and energy, evidences of muscular weakness with intermittent attacks of fever, congestion of the mucous membranes of the eye, with possibly some degree of jaundice, and dropsical swellings of the lower parts of the body, collectively, are strongly suggestive of infectious anemia. The tentative diagnosis will be further strengthened if during and immediately after the febrile period an examination of the blood shows a diminution in the volume of the red corpuscles, an increased rate at which they gravitate, and a decrease of hemoglobin. It must be remembered, however, that in the intervals between the attacks of fever the blood picture promptly returns to normal. In practically all the Bureau's experimental cases, the diminution in the red corpuscles, that is, the anemia, was but transitory, and the corpuscle count returned to normal in the intervals between the attacks of fever even to the last. A few cases were observed, however, in which the anemia was of the progressive type. In one instance the corpuscle count rapidly and progressively diminished until the low level of 1½ million red corpuscles per cubic millimeter was reached.

Infectious anemia in the inactive form would ordinarily not be detected since no clinical symptoms would be present to cause suspicion. It should be remembered also that heavy infestation with intestinal parasites, especially strongyles, produce symptoms that are in some respects similar to those of infectious anemia. Microscopic examinations of the feces for the eggs of these parasites and examination of blood films for evidence of eosinophilia will assist in making a differential diagnosis. It is possible, and in some areas probable, that some horses and mules will have heavy infestation with intestinal parasites and at the same time will be affected with infectious anemia in the chronic form. For further information on strongyle and other intestinal parasites of horses, the reader is referred to Circular 148, Parasites and Parasitic Diseases of Horses.

No laboratory test has yet been found that is specific and at the same time dependable for detecting all affected animals.

CONTROL MEASURES

Preventive vaccination has been attempted by a number of investigators, including those in the Bureau of Animal Industry. In the investigations conducted by this Bureau none of the tissue vaccines prepared from whole blood, blood serum, emulsions of spleen tissue, or emulsions of brain tissue in which the virus was destroyed by formalin, crystal violet, phenol, phenyl mercury acetate, and heat had any appreciable immunizing value.

In searching for an effective treatment many investigators have tried numerous agents such as arsenic preparations, quinine, various dyes, mercurial preparations, and a number of others, but without success. The Bureau experimented with merthiolate, crystal violet, trypan blue, sodium cacodylate, hydrochloric acid, potassium permanganate, fuadin, sulphanilamide, and other preparations, using both acute and chronic cases for these tests. None of the preparations, however, exerted any appreciable influence on the course of the acute disease, nor did any free the chronically infected animals of the virus. Since no specific medication has yet been found for the disease, treatment of affected animals is limited to symptomatic medication, rest, abundance of good feed, and the elimination of intestinal parasites or any other debilitating influences that may be operating.

No instance is known, however, in which an animal proved to be infected with swamp fever ever made a complete recovery with a disappearance of the virus. So far as is known, an animal, when once infected, is always infected. There are instances on record in which horses remained infectious, as proved by horse-inoculation tests, for periods of 14 and 15 years following experimental infection. Because of the fact that there is no definite practical means of diagnosis for the detection of chronic carriers of swamp fever, no systematic program of control can be undertaken.

With the knowledge that the disease may exist in the inactive form and that such animals carry the contagion in the blood stream at all times, the greatest care should always be used to prevent transmission of the disease from animal to animal by unsterilized instruments, bleeding needles, or even hypodermic needles. Until such time as a practical means of diagnosis becomes available and definite information is obtained on the mechanism of infection in the natural state, sanitary measures constitute the best known means of controlling infectious anemia. In those areas where there is reason to believe that many animals are affected with the disease in either a chronic or an inapparent form, the maintenance of good sanitary conditions, systematic control of parasites, attention to the feed, care, and handling of animals will help to hold the ill effects of the disease to a minimum.

U. S. GOVERNMENT PRINTING OFFICE: 1938

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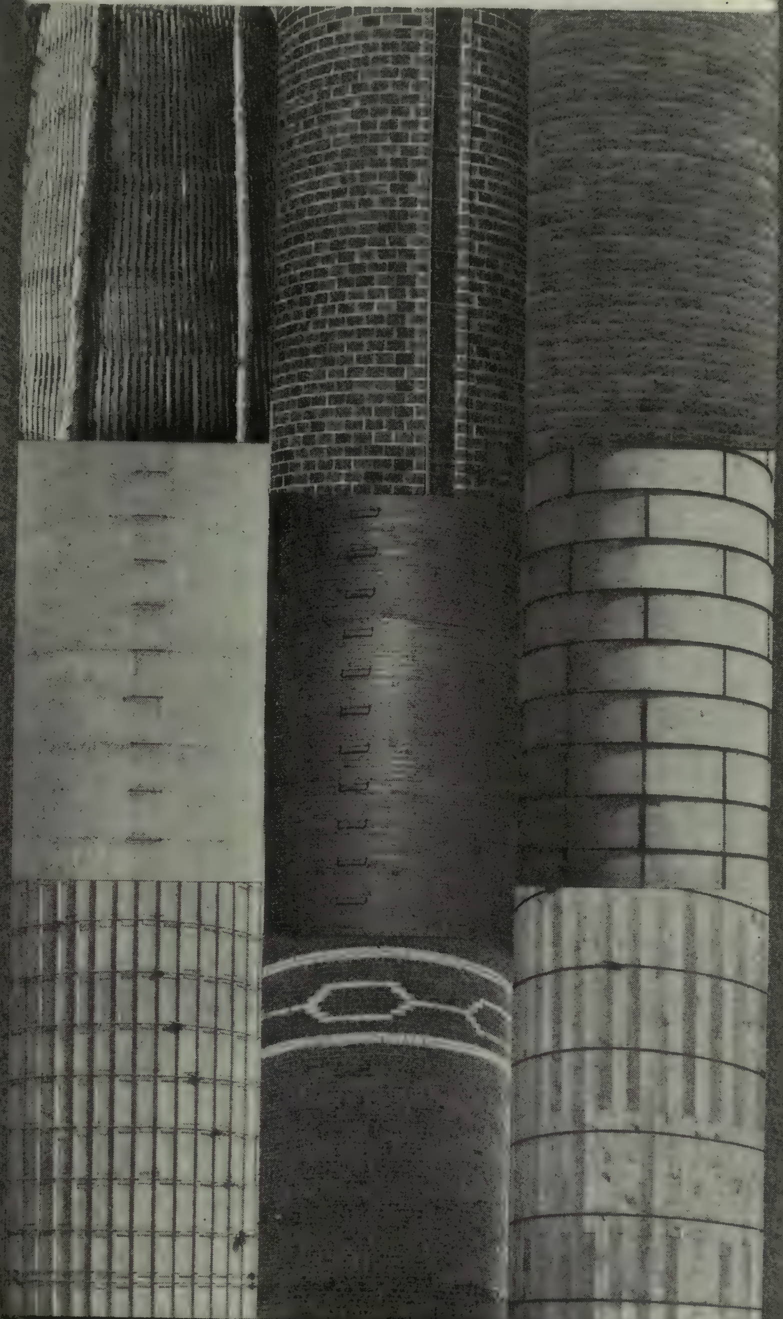
SILOS

TYPES and CONSTRUCTION



FARMERS' BULLETIN No. 1820

GAS DANGER IN SILOS

Suffocating gas from fermenting silage, mostly carbon dioxide, forms in all silos shortly after filling begins and continues until fermentation stops. The gas, being heavier than air, collects and remains in any depression or enclosed space when there is not a strong, free movement of air or the air in the silo is no longer agitated. The above-ground silo, while not free from gas danger, offers better ventilation through its doors, and large quantities seldom accumulate unless the doors are put in too far above the silage level. Gas is a particular hazard in the below-ground silo. Many lives are lost each year because of carelessness in entering a silo where there may be danger of gas. During the filling period the blower on the silage cutter should be run several minutes before anyone enters a silo, and, in the case of a deep pit or any silo into which the distributor pipe does not extend far enough to thoroughly agitate the air, a lighted lantern should be lowered to the bottom to test the air. If the lantern continues to burn, it is safe to enter the silo. If the lantern goes out do not enter until the air can be stirred to dilute the gas by lowering a basket on a rope and lifting and dropping it a number of times or with a blanket, large piece of canvas, or with a tree branch.

A victim of silo gas suffers from lack of oxygen and should be moved into fresh air as soon as possible and artificial respiration applied. Before a rescuer enters the silo a rope should be tied securely to him in case it may be necessary to pull him out. Artificial respiration may be applied by placing the suffocating person prone, with the head to one side, and alternately applying and releasing pressure on the back in the region of the lower ribs, 12 to 15 times each minute. Send for a physician, but in the meantime do not relax efforts to restore breathing.

This bulletin supersedes Farmers' Bulletins No. 825, Pit Silos, and No. 855, Home-Made Silos.

Washington, D. C. **Issued May 1939**

SILO TYPES AND CONSTRUCTION

By J. R. McCalmont, *assistant agricultural engineer, Division of Structures, Bureau of Agricultural Engineering*

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INTRODUCTION

IN A LITTLE MORE than 50 years the silo has become one of the conspicuous buildings of the rural landscape in many parts of the country and is to be found in every State. It has been an important factor in solving the livestock feeding problem, particularly in milk and beef production. Silage is also much used as a feed for sheep and to some extent for horses and mules.[1]

Not all farmers can use silos to advantage, but permanent, upright silos are practical where there is a herd of as many as 10 dairy cows or the equivalent in other livestock for which silage is a good feed. With a smaller number than this the investment in the silo and the machinery needed for filling it generally makes overhead costs too high per animal; also, it is not usually feasible to build a permanent silo small enough so that when few animals are fed the silage will be taken down fast enough to avoid spoilage.

TYPES OF SILOS AND THEIR SELECTION

The kind of silo to build depends upon the investment warranted and the durability desired. In choosing the type several factors must be considered, chief of which are the service requirements, the cash and time available, first cost, upkeep, and durability.

The farmer is the best judge of his service requirements and will determine whether the need for a silo is temporary or permanent, urgent or ordinary, and the availability of cash, labor, and materials. If he is a tenant rather than an owner, a portable or low-cost temporary-type silo may be considered. The farmer in either case is interested in obtaining the most efficient feed storage in keeping with his needs at the least cost.

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[1] See Farmers' Bulletin 578, The Making and Feeding of Silage.

Silos may be divided roughly into above-ground—tower or upright—and the below-ground—pit or trench—silo, either of which may be built for temporary or continued use.

Brick, tile, and concrete silos, when well-built and made of good materials, have the advantage of attractiveness, durability, and fire and wind resistance. Brick and tile are commonly used in regions where ceramic products are readily available or may be shipped in at reasonable cost. Brick are less frequently used than some of the other materials because of the high labor cost incurred in erecting them. This extra cost is sometimes offset by the use of second-grade paving bricks. Because of the action of silage acids on mortar, particular attention must be given to joints.

Well-made concrete silos require little attention except for an occasional coat of paint on the walls. Careful workmanship and the selection of good-quality materials for concrete pay good dividends in lower upkeep costs whether the concrete is in the form of blocks, staves, or monolithic walls. The blocks are least desirable because the quality in many cases is not good enough for this purpose. Concrete staves of good quality are convenient to use as they may be quickly erected without forms, which are required for the monolithic type; however, in many cases sand and gravel are readily available, and the farmer may find it most economical, in spite of the cost of forms and the greater quantity of material, to build the monolithic type.

Of the many types of wood silos, the most common is built of milled staves, the life of which varies with the kind of wood and its treatment. The less-durable woods are creosoted. Such silos require hoops or bands, which must be loosened at filling time to avoid crushing the staves by swelling and should be tightened when the silo is empty to avoid collapse when the silo dries out. Such silos may be troublesome if these precautions are neglected. Other forms of wood silos are discussed later and can be built at relatively low first cost, if farm labor and local materials are used. The life of such silos may be relatively shorter than that of silos built of more durable materials, but very satisfactory service may be obtained if they are carefully built in accordance with the directions given in this bulletin.

A metal silo is relatively easy to erect and, if rust resistant and kept painted, it is durable. Naturally, it is fireproof, but may buckle and be badly damaged by a fire near it. In regions of heavy winds it needs firm anchorage, particularly when empty. Costs vary with the gage and kind of metal and with freight rates.

One of the temporary types may be used in an emergency such as that brought about by drought, destruction of buildings by fire, or some other unforeseen circumstance. They are sometimes used in place of more durable silos when sufficient money is not available to build a more substantial structure. It must be remembered that the percentage of spoilage in these silos is higher than in the more substantial structures.

ABOVE-GROUND PERMANENT SILOS

GENERAL

To provide for low depreciation and to keep down spoilage of silage, the above-ground silo must have certain construction features:

CONSTRUCTION REQUIREMENTS

1. The walls should be airtight. In wood silos lumber should be well matched and contain no large knots. Doors must fit tightly.
2. Walls should be smooth and plumb and circular in form for structural strength and to permit free settling and packing of silage to avoid air pockets. Square, hexagonal, or octagonal silos are sometimes made when farm-cut lumber is used, but are not recommended.
3. Walls should withstand considerable lateral strain without cracking or bulging. Lateral pressures increase directly with the depth of silage and vary with the kind of silage stored. The deeper the silage the greater the average capacity per foot of depth. The higher the pressure the more air is squeezed out and the less spoilage.
4. Exterior wall surfaces should be protected where necessary to retard weathering or decay.
5. The foundation must be well drained and of ample size and strength to support the load and to avoid uneven settlement and cracking of the walls.
6. The silo should have a chute to facilitate feeding, and a safe ladder giving access to the filling door.
7. A roof is desirable in regions of heavy snow or rain or extreme cold.

LOCATION

Most commonly on dairy farms an upright silo is located a few feet from the barn and is connected with a separate feed room; the barn door can then be closed at milking time and the silage odors kept out. Where silage is fed to beef cattle the silo is often placed away from other buildings but handy to the feed lots. The bottom of the silo should not be more than 5 feet below the lowest door.

SIZE AND CAPACITY

The correct diameter of the silo depends upon the quantity of silage to be fed daily. The silage should be removed at the rate of 2 to 3 inches a day, depending upon the air temperature. The warmer the weather the more must be removed daily to prevent spoilage. In winter probably 2 inches a day should be removed (table 1). A common error in building is to make the diameter too large for the size of the herd. If the herd is reduced in size to a point where the low consumption results in spoilage when silage is fed off the entire surface, the losses may be reduced by feeding off to a depth of 1 to 2 feet on alternate halves. When silage is needed for large herds, several silos are generally built. This practice allows different crops to be ensiled and fed either separately or together.

TABLE 1.—*Relation of size of herd to diameter of silo for winter feeding, on the basis of 40 pounds of silage per cubic foot and the removal of 2 inches of silage daily to avoid spoilage*

Inside diameter of silo (feet)	Volume per foot of depth	Amount to be removed—			Animals that may be fed with a daily allowance per head of—			
		Daily	For a feeding period of—					
			180 days	240 days	40 pounds	30 pounds	20 pounds	15 pounds
	Cubic feet	*Pounds*	*Tons*	*Tons*	*Number*	*Number*	*Number*	*Number*
10	78.5	524	47	63	13	17	26	35
11	95.0	634	57	76	16	21	31	42
12	113.1	754	68	90	19	25	37	50
13	132.7	885	80	106	22	29	44	59
14	153.9	1,027	92	123	25	34	51	68
15	176.7	1,178	106	141	29	39	59	78
16	201.0	1,340	120	161	33	44	67	89
17	227.0	1,513	136	182	38	50	75	101
18	254.5	1,696	153	203	42	56	85	113
20	314.2	2,094	188	251	52	70	104	139

The weight of a cubic foot of silage varies (see table 4) with depth in the silo, rate of filling, length of cut, maturity of material, and moisture content. Corn silage, put up when about 75 percent of the grain has passed the milk stage and containing approximately 70 percent moisture, is considered normal silage. Knowing the quantity of silage to be fed daily, it is possible to estimate the diameter of the silo necessary to permit the removal of a certain depth each day. Table 1 shows the proper diameter of the silo for herds of different sizes for winter feeding, when a 2-inch depth of silage is to be removed daily.

A 900-pound cow ordinarily eats 30 pounds of silage a day and a 1,200-pound cow about 40 pounds. Yearlings eat about half as much as mature animals; fattening cattle, 25 to 35 pounds for each 1,000 pounds live weight. A sheep takes about one-eighth as much as a cow, and work horses should be limited to 15 or 20 pounds daily. Particular care should be taken to avoid feeding moldy silage to horses.

The practice of using silage instead of soiling crops to supplement pastures during summer droughts and in the early fall is becoming common. For such feeding the daily ration for each cow may be as low as 10 pounds, depending upon the amount and quality of pasture or other succulent feeds available. For the same herd the silo for summer feeding should be of smaller diameter than the one used for winter feeding, since 3 inches instead of 2 are to be removed daily. To provide for summer feeding of small herds an additional silo of smaller diameter is desirable. Table 2 shows the relation between the size of the herd and the diameter of the silo when 3 inches of silage is removed daily.

TABLE 2.—*Relation of size of herd to diameter of silo for summer feeding, on the basis of 40 pounds of silage per cubic foot and the removal of 3 inches of silage daily to avoid spoilage*

Inside diameter of silo (feet)	Volume per foot of depth	Amount to be removed—				Animals that may be fed with a daily allowance per head of—			
		Daily	For a feeding period of—						
			30 days	45 days	60 days	30 pounds	20 pounds	15 pounds	10 pounds
	Cubic feet	*Pounds*	*Tons*	*Tons*	*Tons*	*Number*	*Number*	*Number*	*Number*
10	78.5	785	12	18	24	26	39	52	78
11	95.0	950	14	21	28	31	47	63	95
12	113.1	1,131	17	25	34	38	56	75	113
13	132.7	1,327	20	30	40	44	66	88	132
14	153.9	1,539	23	35	46	51	77	102	154
15	176.7	1,767	27	40	54	59	88	118	177
16	201.0	2,010	30	45	60	67	100	134	201

In general the height of the silo should not be less than twice nor more than three and one-half times the diameter. The greater the depth the better the quality of silage and the greater the unit capacity. Extreme heights should be avoided because of the excessive power required to elevate the cut corn.

Table 3, based on the average weights of silage actually placed in five silos at the Department's Research Center at Beltsville, Md., over a period of several years, indicates the required depth of the silo. For example, a herd of 25 cows fed 30 pounds per head daily for a period of 240 days will need 90 tons of silage (table 1) and will require a silo 12 to 14 feet in diameter. Table 3 shows that, with some allowance for loss by waste and spoilage, a 12- by 38-foot or a 14- by 30-foot silo will be satisfactory for this herd.

TABLE 3.—*Capacity of silos with different diameters and depths of silage* [1]

Depth of silage (feet)	Capacity with an inside diameter of—										
	10 feet	11 feet	12 feet	13 feet	14 feet	15 feet	16 feet	17 feet	18 feet	19 feet	20 feet
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
20	27										
22	30	37									
24	24	41	49								
26	38	46	55	65							
28	43	52	61	72	84						
30	47	57	68	80	92	106	121				
32	51	62	74	87	100	115	131	148			
34	56	67	80	94	109	125	142	161	180		
36		73	86	101	117	135	153	173	194	216	
38			93	109	126	145	165	186	209	233	258
40			100	117	135	155	177	200	224	249	276
42				124	144	165	188	212	237	264	293
44					152	174	198	224	251	279	310
46						184	209	236	265	295	327
48							220	248	279	310	344
50								261	293	326	361

[1] Capacities given are for normal corn silage when the silo is filled at the average speed of 20 to 50 tons per day with 1 man in the silo and refilled once after silage has settled.

A farmer may wish to know approximately the amount of silage in a partially emptied silo. Tables can give only a rough estimate as a substitute for weighing since unit weight of silage is affected by many factors. However, table 4, based on the weight of well-settled silage, permits the making of such an estimate. For example, if a 14- by 45-foot silo contains 40 feet of settled silage and 20 feet has been removed, more than half of the silage by weight remains because the lower 20 feet is more compact than the upper 20 feet. The volume of 1 foot of depth of silage is found from table 1 to be 153.9 cubic feet. Table 4 gives the average weights of silage as 34.9 and 47.0 pounds per cubic foot at 20 and 40 feet, respectively; 40×153.9×47=289,332 pounds in the silo before feeding started. Subtracting the silage removed from the upper 20 feet—20×153.9×34.9=107,422, leaves 181,910 pounds, or about 91 tons.

TABLE 4.—*Weight of settled silage per cubic foot at a given depth and the average weight to that depth when the silo is full*

Depth of settled silage (feet)	Weight per cubic foot at given depth	Average weight per cubic foot	Depth of settled silage (feet)	Weight per cubic foot at given depth	Average weight per cubic foot	Depth of settled silage (feet)	Weight per cubic foot at given depth	Average weight per cubic foot
	Pounds	*Pounds*		*Pounds*	*Pounds*		*Pounds*	*Pounds*
1	18. 5	18. 5	15	42. 0	31. 3	28	57	40. 2
2	20. 8	19. 7	16	43	32. 1	29	58	40. 8
3	23. 0	20. 8	17	44. 5	32. 8	30	59	41. 4
4	24. 9	21. 8	18	45. 8	33. 5	31	60	42. 0
5	26. 8	22. 8	19	47	34. 2	32	60. 9	42. 7
6	28. 5	23. 8	20	48. 1	34. 9	33	61. 9	43. 2
7	30. 2	24. 7	21	49. 4	35. 6	34	62. 8	43. 7
8	31. 8	25. 6	22	50. 5	36. 3	35	63. 5	44. 3
9	33. 5	26. 4	23	51. 6	36. 9	36	64. 3	44. 9
10	35	27. 3	24	52. 5	37. 6	37	65. 1	45. 4
11	36. 5	28. 1	25	54	38. 2	38	65. 9	45. 9
12	38	28. 9	26	55. 0	38. 9	39	66. 6	46. 5
13	39. 5	29. 8	27	56	39. 5	40	67. 4	47. 0
14	40. 8	30. 6						

The sale price of silage often may be based on its equivalent feeding value with respect to corn and hay. A ton of silage in Illinois ordinarily contains 4.6 bushels of grain, and the stalks and leaves approximate a value of 270 pounds of mixed hay. The feeding value of the silage is about one-third of the value of good leafy alfalfa hay. Hence the local price of hay and grain may be used to determine a fair price for sale or for trading. These data in conjunction with table 4 are often useful for farm inventory and other purposes.

COST

The cost of constructing a silo varies with the size, type, and price of materials and labor. In general a silo built of local materials, with farm labor, will cost the least. Table 5 gives a rough estimate of the cost of permanent upright silos.

TABLE 5.—*Approximate cost of permanent upright silos per ton of stored silage (roof and chute included)* [1]

Capacity	Cost	Capacity	Cost
Tons	*Dollars*	*Tons*	*Dollars*
25–50	7–12	100–150	4–8
50–100	5–9	150–200	4–7

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[1] These figures, based on heights of from 2 to 3½ times the diameter, were compiled from actual costs to farmers, contractors' estimates, and manufacturers' and dealers' retail price lists for 1937.

HOW TO OBTAIN PLANS

Most of the extension services of the State agricultural colleges can furnish plans for the types of silos commonly used in their States or can indicate where information on special types of silos can be obtained. Many of the State agricultural colleges have bulletins on silos.

FOUNDATIONS

Foundations stand up well only on firm well-drained soil, and only if they extend below the frost line. In the North it is desirable that they extend 4 feet or more below the ground surface; in the South at least 2 feet. The width of the foundation base needed varies with the condition of the soil and the load to be supported. The foundation must be wider on loose soil than on firm soil. Recent investigations have shown that the walls carry from 30 to 60 percent of the total weight of silage depending on the roughness of the walls and the character of the silage. Tests by the Bureau of Agricultural Engineering in a 14- by 45-foot monolithic concrete silo showed that 60 percent of the weight of normal corn silage was supported by the walls.

Table 6 lists the expected foundation loads per foot of circumference of silo wall and the width of footings needed. The footing sizes are based on firm, dry soil with a load-bearing capacity of at least 2½ tons per square foot. If a tall silo is to be built, a reliable local builder should be consulted as to the bearing value of the subsoil and the proper width of footings to use. The foundation should be placed on uniform bearing, not part rock and part soil, and may be of concrete, brick, or stone. Where hard-burned brick are cheap, as is often the case near a brickyard, they can be used to advantage for a foundation. They should be laid in cement, not in lime mortar. If the foundation extends more than 1 foot above the surface of the ground it should be reinforced the same as the walls. Stone makes a good foundation, but in most areas concrete is stronger and generally cheaper than brick or stone.

TABLE 6.—*Loads on footings per foot of circumference of silos of different heights and the width of footings needed on soil of 2.5 tons per square foot bearing capacity*

Height of silo wall (feet)	Load and width of footings for silo walls of—							
	Concrete				5-inch tile		Wood (2-inch) or metal	
	6-inch monolithic		2-inch stave					
	Load per foot of circumference	Width of footings	Load per foot of circumference	Width of footings	Load per foot of circumference	Width of footings	Load per foot of circumference	Width of footings
	Tons	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*	*Tons*	*Inches*
20	2.0	10	1.5	8	1.5	8	1.4	7
30	3.1	16	2.3	11	2.3	12	2.1	10
40	4.6	22	3.6	18	3.6	18	3.3	16
50	5.7	27	4.5	22	4.5	22		

The foundation for a round silo can be laid out as follows: Using a 2- by 4-inch scantling a little longer than one-half the diameter of the silo plus the width of the foundation walls, drive a fortypenny spike through one end of it and into the top of a stake set where the center of the silo bottom is to be. From the spike measure off on the scantling the distance to the outside of the foundation wall and nail on a marker with which to lay off the foundation line as shown in figure 1.

If the building site is not level, the marker should be lengthened (fig. 1) and moved up or down so the scantling can be held level as it is moved to mark out the foundation circle. On very uneven ground it may be difficult to make the line continuous, in which case points should be marked every few inches and joined afterward.

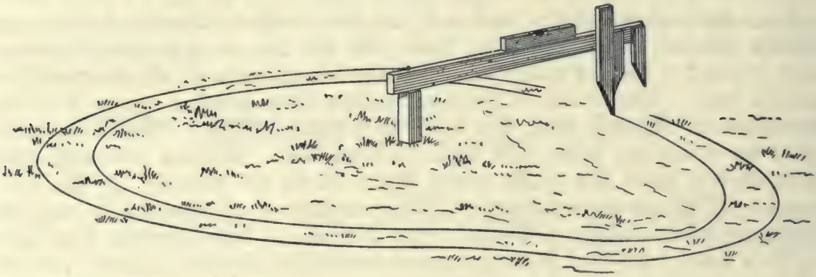


FIGURE 1.—Method of laying off the foundation for a silo.

In firm soil the earth between the two lines can be excavated, leaving a trench the walls of which serve as forms for a concrete foundation. Otherwise the earth inside the outer circle must be excavated to firm ground below the frost line. A plumb line should be used so that the walls can be dug true. Generally the earth is firm enough to stand without danger of caving, and, lined with tar paper, may serve as an outside form in building the foundation, (fig. 2, *A*).

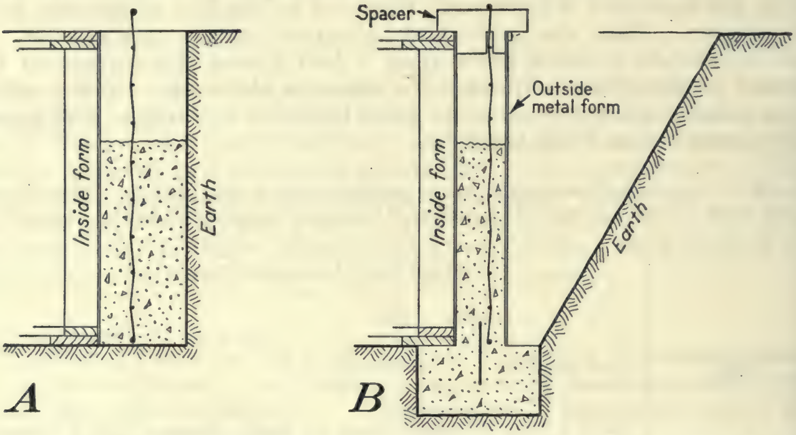


FIGURE 2.—*A*, Method of constructing foundations without footings for silos with pits in firm soils; *B*, method used for silos with pits when footings are required.

If the dirt caves in, the foundation should be built as shown in figure 2, *B*, in which case the pit must be dug large to give ample room for placing and removing the outside form. Many failures of masonry structures have been caused by poor and insufficient foundations. If there is no good location for a foundation and the silo is very large it is well to put in a special footing to distribute the weight over a larger area. (See fig. 2, *B*, and table 6, for footing loads and sizes.) Another way to get wider weight distribution is to build the foundation and floor in one piece.

If the silo is to be built without a pit, the marker is moved toward the center stake a distance equal to the width of the wall or footing and a second circle laid off.

Figure 3 illustrates how forms are built for a foundation wall extending above ground and how the anchors are placed for holding the walls. The anchors may be machine bolts, strap iron, eyebolts, or reinforcing iron, according to the type of silo planned. These are located in the foundation and spaced so as to be easily fastened and give firm anchorage to the wall. In masonry silos the wall reinforcing extends into the foundation or the footing. For stave and wood silos the inside diameter of the foundation wall should be 4 inches less than the inside diameter of the silo, making a 2-inch shoulder between the inside of the silo wall and the inside of the foundation to allow for shrinkage movement of staves, and imperfections in the wall.

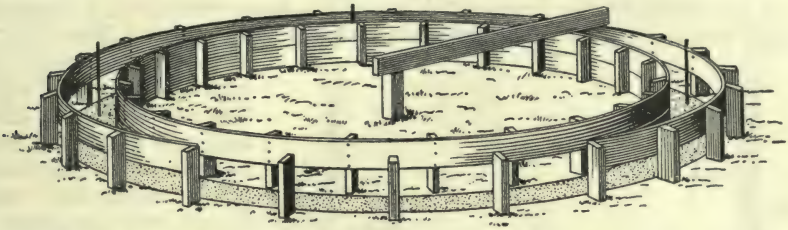


FIGURE 3.—Form for foundation extending above ground, partly boarded up.

When concrete is used the following brief information is helpful:

Use a standard portland cement, keeping the sacks of cement in a dry place and off the ground. Obtain a good, clean, coarse sand and clean, coarse aggregate of gravel or broken stone graded in size from ½ to 1½ inches; mix these together with water free from acids or alkali. Water fit to drink is suitable for concrete, but drainage water from the barnyard or muddy water should not be used. Mix the concrete to a jellylike consistency with the least water that will give easy delivery to forms without being sloppy. About 4 or 5 gallons of water to a sack of cement is ordinarily required, the quantity varying with the dryness of the aggregate. Except for very large silos a 1 : 2½ : 4 concrete is suitable for foundations.

Satisfactory concrete may be obtained either by hand or machine mixing, but machine mixing is recommended. Some mixtures commonly used for stucco plaster, footings, and walls are given in table 7, which is useful for estimating the quantity of material required. A sack of cement is approximately 1 cubic foot.

TABLE 7.—*Proportions and approximate quantities of materials required for making 1 cubic yard of concrete in place*

Proportion of the ingredients			Quantity of material[1]		
Cement	Sand	Gravel or stone	Cement	Sand (damp and loose)	Gravel (loose)
			Sacks	*Cubic yards*	*Cubic yard*
1	1.5		15.5	0.86	
1	2.0		12.8	.95	
1	3.0		9.6	1.07	
1	2.0	3.5	6.5	.48	0.84
1	2.5	4	5.6	.52	.83
1	2.5	5	5.0	.46	.92
1	3.0	5	4.6	.51	.85

[1] Quantities may vary as much as 10 percent, depending on the aggregate.

More complete information on mixing and placing concrete is given in Farmers' Bulletin 1772, Use of Concrete on the Farm, and in booklets obtainable from cement dealers.

FLOORS

If the earth in the bottom of the silo is firm, porous and comparatively dry, no provision need be made for drainage and a floor may be omitted; however, a concrete floor will make the silo easier to clean and will keep rats from burrowing underneath the foundation wall. If natural drainage is not good a drain should be laid, open at the center of the concrete floor and sloping away from the wall to an outlet. Where grass or legume and molasses or other high moisture silage is made several drains through the foundation wall are often effective in removing excess juices. These drains generally are placed above ground and may be fitted with plugs, caps, or valves to prevent the entrance of air when drainage ceases (fig. 4).

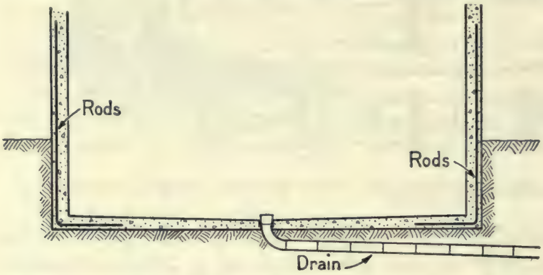


FIGURE 4.—Tile floor drain.

The floor should be at least 4 inches thick and may have a sealing joint of tar between it and the wall. In very soft soil the foundation load may be distributed over the entire floor by pouring the foundation and floor as a unit and using reinforcing bars 12 to 18 inches apart extending across the floor and into the foundation wall.

REINFORCING

All silos must be reinforced to withstand the pressures exerted by the silage and by high winds. The amount of reinforcing needed depends on the dimensions of the silo and the crop stored. If a silo is used for other than corn silage, it is well to provide for the maximum probable load. Tests made by the Bureau of Agricultural Engineering gave an average horizontal pressure of 11 pounds per square foot per foot of depth of corn silage, which is too low for silage of sunflower, pea vine, hay and molasses, or very high-moisture corn. Tests indicate that it is advisable to use a unit pressure for hay and molasses silage approximately one and three-fourths times that for normal corn silage, or about 19 pounds per square foot per foot of depth. Tables 8 and 9 are based on these pressures and give the sizes of horizontal reinforcing required for any type of silo. Wood or concrete stave silos are reinforced with hoops placed around the outside; in masonry silos, such as tile, brick, or concrete block, the reinforcing is of wire, round or square rods, or iron flats placed in the mortar joints between courses. Hoops must be properly spaced and tightened. To avoid stripping, each nut should be given enough turns to show several threads outside the nut. Hoops should have rolled threads so as not to reduce the cross-sectional area of the rod, and the next larger size of nut. They may be either plain or galvanized. Painting plain hoops prevents weakening by rust and unsightly stains on the walls.

TABLE 8.—*Number of pieces of No. 3 reinforcing* [1] *wire or ⅜-inch round bars required in masonry silos for horizontal reinforcing when spaced at 1-foot intervals* [2]

Distance below top (feet)	Pieces of reinforcing for silos of diameter indicated to store—											
	Corn silage						Hay and molasses silage					
	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet	10 feet	12 feet	14 feet	16 feet	18 feet	20 feet
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Top	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1	1	1	1
4	0	0	0	0	1	1	0	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	2
6	0	0	0	1	1	1	1	1	1	1	2	1
7	1	1	1	1	1	1	1	1	1	2	1	2
8	0	1	1	1	1	1	1	1	2	1	2	2
9	1	0	1	1	2	2	1	2	1	2	2	2
10	1	1	1	2	1	1	2	1	2	2	2	3
11	1	1	1	1	2	2	1	2	2	2	2	2
12	1	1	2	2	1	2	2	1	2	2	3	3
13	1	1	1	1	2	2	1	2	2	3	2	3
14	1	2	2	2	2	2	2	2	3	2	3	1
15	1	1	1	2	2	2	2	2	2	3	3	2
16	1	2	2	2	2	2	2	2	3	3	1	1
17	2	1	1	2	2	3	2	3	3	3	2	2
18	1	2	2	2	2	2	2	2	3	1	2	2
19	2	1	2	2	2	3	2	3	3	2	2	2
20	1	2	2	2	3	2	3	3	1	2	2	2
21	2	1	2	3	1	1	1	1	2	2	2	2
22	1	2	2	2	2	2	2	2	1	2	2	3
23	2	2	2	3	1	1	1	1	2	2	2	2
24	2	2	2	2	2	2	2	2	1	2	3	3
25	2	2	2	3	1	1	1	2	2	2	2	2
26	2	2	3	1	2	2	2	2	2	2	3	3
27	2	2	2	2	1	1	1	2	2	2	2	3
28	2	2	3	1	2	2	2	2	2	3	3	3
29	2	3	2	2	1	2	1	2	2	2	2	3
30	2	2	3	1	2	2	2	2	2	3	3	3
31	3	3	1	2	2	2	1	2	3	2	3	3
32	2	2	2	1	2	2	2	2	2	3	3	3
33	3	3	1	2	2	2	2	2	3	3	3	4
34	2	3	2	1	2	2	2	2	2	3	3	3
35	3	3	1	2	2	2	2	2	3	3	3	4
36	------	3	2	2	2	2	------	3	2	3	4	3
37	------	3	1	2	2	2	------	2	3	3	3	4
38	------	3	2	2	2	3	------	3	2	3	4	4
39	------	3	1	2	2	2	------	2	3	3	3	4
40	------	3	2	2	2	3	------	3	3	3	4	4
41	------	------	2	2	2	2	------	------	3	4	4	4
42	------	------	2	2	2	3	------	------	3	3	4	4
43	------	------	2	2	3	2	------	------	3	4	4	5
44	------	------	2	2	2	3	------	------	3	3	4	4
45	------	------	2	2	3	3	------	------	3	4	4	5
46	------	------	------	2	2	3	------	------	------	4	4	4
47	------	------	------	3	3	3	------	------	------	4	4	5
48	------	------	------	2	2	3	------	------	------	4	5	5
49	------	------	------	3	3	3	------	------	------	4	4	5
50	------	------	------	2	2	3	------	------	------	4	5	5

[1] The cross-sectional areas of the different sizes of reinforcing wire and bars are: No. 3, 0.0467 square inch; ⅜-inch rods 0.1105 square inch. All figures below the horizontal line represent pieces of ⅜-inch round bars.

[2] This amount of reinforcing steel is based on a safe working stress of 18,000 pounds per square inch and can be spaced 4, 8, 12, 15, 24, or 30 inches according to the type of material and the size of the units used to build the silo.

TABLE 9.—*Spacing of $\frac{9}{16}$-inch hoops*[1] *for stave silos*

Distance of hoop below top (feet)	Corn silage (diameter in feet)						Hay and molasses silage (diameter in feet)					
	10	12	14	16	18	20	10	12	14	16	18	20
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
0–2½	30	30	30	30	30	30	30	30	30	30	30	30
2½–5	30	30	30	30	30	30	30	30	30	30	30	30
5–7½	30	30	30	30	30	30	30	30	30	30	30	30
7½–10	30	30	30	30	30	30	30	30	30	30	30	30
10–12½	30	30	30	30	30	30	30	30	30	15	15	15
12½–15	30	30	30	30	30	30	30	30	15	15	15	15
15–17½	30	30	30	30	30	15	30	15	15	15	15	15
17½–20	30	30	30	30	15	15	15	15	15	15	15	10
20–22½	30	30	30	15	15	15	15	15	15	15	10	10
22½–25	30	30	15	15	15	15	15	15	15	10	10	10
25–27½	30	30	15	15	15	15	15	15	15	10	10	10
27½–30	30	15	15	15	15	15	15	15	10	10	10	7½
30–32½	30	15	15	15	15	15	15	10	10	10	7½	7½
32½–35	15	15	15	15	15	10	15	10	10	10	7½	7½
35–37½	------	15	15	15	10	10	------	10	10	7½	7½	7½
37½–40	------	15	15	15	10	10	------	10	10	7½	7½	5
40–42½	------	------	15	10	10	10	------	------	7½	7½	7½	5
42½–45	------	------	15	10	10	10	------	------	7½	7½	5	5
45–47½	------	------	------	10	10	10	------	------	------	5	5	5
47½–50	------	------	------	10	10	10	------	------	------	5	5	5

[1] Based on 18,000 pounds per square inch safe stress. All hoops to have rolled threads and nuts of the next larger size.

In a monolithic concrete silo the material used for reinforcement may be steel rods, bars, or wire mesh, provided the amount used is sufficient to withstand the pressure. The material most convenient and readily obtained at a reasonable cost is the common woven or welded steel-mesh reinforcing cloth, 32 or 36 inches wide, with horizontal wires ranging from No. 9 to No. 3 or larger. The horizontal strength per square foot of this reinforcing should correspond to sizes given in table 8. This wire is readily placed in position and is not easily displaced while the form is being filled. Reinforcing wire should be free from sharp kinks or bends, and to be most effective, should be placed within 1 or 2 inches of the outer wall (fig. 2, *B*). Old or damaged wire of unknown strength should never be used.

The length of wire-mesh strip for a given diameter of silo is given in table 10, which is based on reinforcing having No. 3 wires for horizontal stands. This allows about 12 inches for lapping and securely fastening the ends by binding with No. 16 soft-iron wire to prevent slipping. Each strip of wire should also be fastened to the strip below by the same means. If ⅜-inch bars are used they should lap 18 inches.

TABLE 10.—*Length of wire-mesh sections for reinforcing concrete wall*

Diameter of silo (feet)	Length of strips required to make circumference[1]		Diameter of silo (feet)	Length of strips required to make circumference[1]		Diameter of silo (feet)	Length of strips required to make circumference[1]	
	Feet	*Inches*		*Feet*	*Inches*		*Feet*	*Inches*
10	34	9	13	44	2	16	53	7
11	37	11	14	47	4	17	56	9
12	41	1	15	50	6	18	60	0

[1] Includes 12 inches for lap and fastening.

DOORS AND DOORWAYS

Silo doors must close tightly to prevent air leakage and must be flush with the inner wall to avoid formation of air pockets as silage settles. Frames must be strong to resist silage pressure.

Two kinds of door openings are in general use—intermittent and continuous. A common size for doors is 20 inches wide by 30 inches high. The vertical space between the intermittent doorways is from 2½ to 3 feet.

The continuous doorway is convenient for the removal of silage, but particular care is necessary in framing it to obtain the desired strength. Special features of door construction particularly adapted to different types of silos are described later. Doors may be fitted with hooks or hinges so they can be closed or replaced as the silo is emptied, a procedure that reduces draft through the silo and makes working conditions more comfortable and prevents loss or misplacing of doors.

CHUTES

A chute is desirable on all silos to prevent the scattering of silage. In building the doorframe provision should be made for the attachment of the chute. If the chute is not too large, climbing the silo will be more convenient and safer. If a continuous doorway is used, the reinforcing rods across it will serve as a ladder; otherwise a ladder must be attached to the chute. Bolt holes for the attachment of the chute may be left in a concrete wall by placing square, tapered wood pins or pieces of cornstalks in the wall as the forms are being filled. These pins should be greased so they may be easily punched out. The form of chute and the material used will vary with the type of silo, as may be seen by referring to figures 20, 23, and 31.

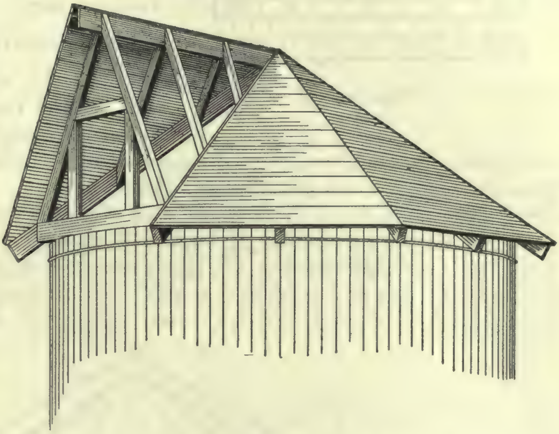


Figure 5.—Roof with space for glazed window in gable.

ROOFS

A roof is not essential, but it is desirable for several reasons: It adds to the stability, appearance, and life of the silo, retards freezing, reduces spoilage by keeping rain and snow out, discourages pigeons and sparrows from feeding on the silage, and makes the work of removing silage more agreeable. A simple trap door in the roof to admit the silage carrier or blower pipe is sufficient but a glazed dormer window in a roof framed as illustrated in figure 5 admits light and makes the use of artificial light less necessary. When electricity is available lights with reflectors in the top of the chute and roof are a great convenience and should be provided when the silo is constructed. The filling door should be easily accessible from the ladder or chute.

When the door is across the silo from the chute a catwalk is a necessity for safety in placing or removing the blower pipe.

Gambrel, dome, and half-pitch roofs are most economical of space and provide more headroom for maximum filling (fig. 6). In some cases the roofs may be made of galvanized metal with movable sections which open and allow filling to the top. The form of anchorage for the roof plate will vary with the type of construction; with stave silos, strap bolts passing through the plate and bolted to the tops of the staves are used; with masonry silos, anchor bolts may be set in concrete (fig. 7), or in top courses of tile or brick. On masonry silos a strong and durable roof may be made of a thin shell of concrete poured in a conical form.

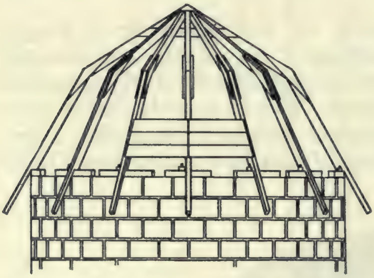


FIGURE 6.—Framing for a gambrel roof.

LIGHTNING PROTECTION

The silo, usually the tallest building in the farmstead group, forms a natural target for lightning. Destruction of wood silos or serious damage to those of masonry may be greatly reduced by installing lightning rods. (See Farmers' Bulletin 1512, Protection of Buildings and Farm Property from Lightning). The air terminal should be securely fastened to the peak of the roof and the cable extending to the ground firmly attached by a strong fastener to the silo roof and walls. The electrical connection may be completed by extending the down conductor to a ground 8 or 10 feet deep reaching soil permanently moist. Place the down conductor where it will not be easily damaged by wagons or trucks and protect from injury if necessary. If the nearby barn is rodded, cross connect to the nearest down conductor on the end of the barn.

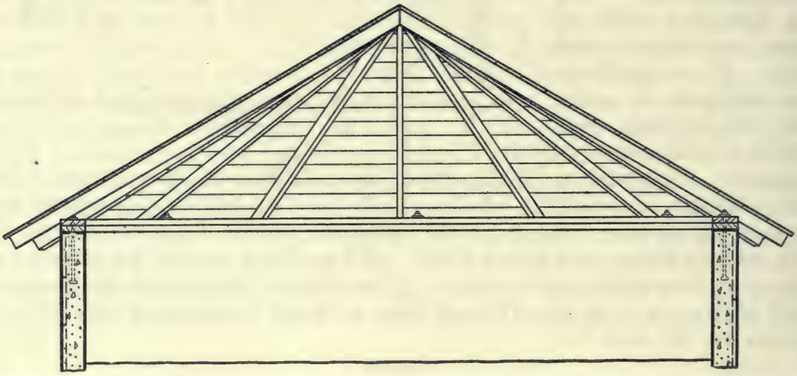


FIGURE 7.—Pitch-roof construction showing anchorage of plate to a masonry wall.

SCAFFOLDING

Safety is of first importance in the erection of scaffolding. In building high silos it is particularly important that the scaffold uprights be plumb and firmly braced. It is a good practice to set them in the ground 4 to 6 inches. Uprights of 2- by 4-inch scantling doubled and overlapping at the joints are convenient. However, long straight poles can often be obtained on the farm at lower cost. The number of uprights needed will vary from 7 for a small silo to 17 or more for a larger one when inside scaffolding is used (figs. 8 and 10). The uprights are usually braced to a center pole.

In the erection of most silos inside scaffolding is used, but wood-stave silos require an outside scaffold. Such outside scaffolding is made up of pairs of upright posts connected with horizontal bars spaced at intervals required for the working platform. From 8 to 18 or more pairs are needed, the inner posts placed about 1½ feet from the silo wall so as to leave a clear working space and connect the pairs with horizontal and diagonal braces, as shown in figure 9.

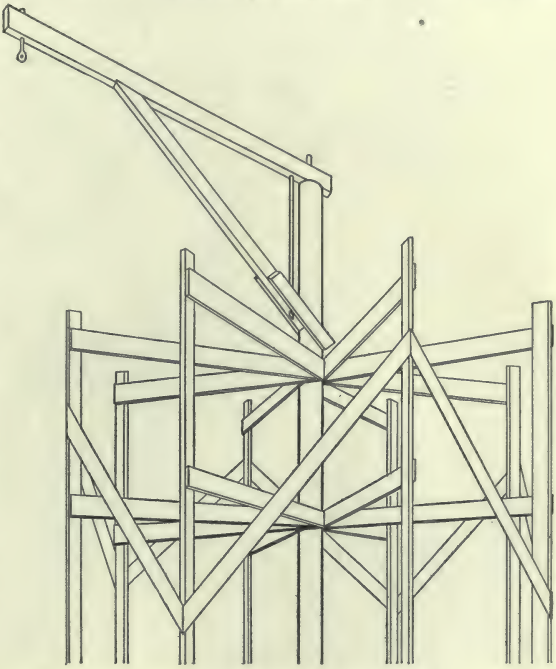


FIGURE 8.—Top portion of inside scaffolding showing rotating device for hoisting concrete.

WALL TREATMENTS FOR NEW AND OLD SILOS

Any painting or treating of the walls of a new silo deemed desirable is best done before the scaffolding is removed. The interior surface of walls should be smooth. Any coating applied should have a smooth lasting finish, be impervious to silage acids, and stop air and water leakage. Some of the common coatings effective for a few seasons are plaster or cement wash for masonry walls and asphalt or commercial bitulithic paints for all kinds. Creosoted wood staves need no further treatment for several years. Silage acids have no effect on hard glazed tile, and for this reason some manufacturers make special silo tile that fit closely on the inside, leaving very little mortar exposed. Well-made concrete is highly resistant to these acids, but careless mixing and poor workmanship in placing may result in rapid deterioration. Special treatment of the interior surface of a silo will not adequately protect poor-quality concrete. It is much more effective to use high-quality concrete in the silo wall itself in the first place. A wash of cement and water of the consistency of thick paint may be applied to the wetted concrete wall to cover irregularities. Among the best known coatings to prevent action of silage acids are linseed oil and asphalt or coal tar thinned with gasoline. This coating may be renewed from year to year as required. When asphalt or tar is applied, the usual gasoline precautions should be observed.

A cement wash may be made with portland cement and iron filings. This mixture requires 4½ pounds of water, 10 pounds of cement, and 2½ pounds of No. 126 iron filings for a batch that will cover 110 square feet. The mixture must be stirred frequently to keep the filings from settling out. Iron filings can be obtained either with or without sal ammoniac. Sal ammoniac hastens the rusting of the filings.

Because galvanized metal is readily attacked by silage acids, new silos of this material are painted inside with refined coal tar thinned with gasoline or linseed oil. Commercial preparations are also available for this purpose. Aluminum-flake paint may be used on the exterior to improve the appearance.

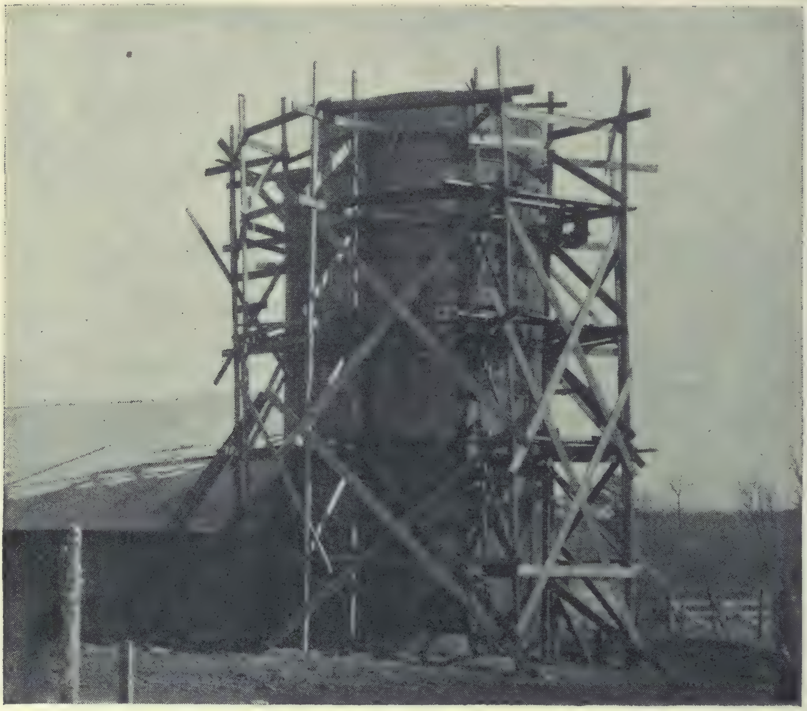


FIGURE 9.—Outside scaffolding for erecting a wood silo.

The life of a silo can be extended by proper upkeep and repair. Some farmers paint their silos each year after the silage is fed out, using a low-cost preparation. Others apply more lasting coatings once in 2 to 5 years.

Old masonry silos having poor mortar joints can be reconditioned by cleaning the walls, pointing joints and cracks with rich cement mortar, and then painting them with a tar or asphaltic preparation. This is highly important with block or brick walls, where the reinforcing is between courses, for once the reinforcing has rusted out it cannot be replaced without tearing down the silo. Where the walls leak, a coat of rich cement plaster might well be added.

Concrete staves should be similarly protected against injury from silage juice. Since they are generally 2½ to 3 inches thick there is not much safety margin for reduction in strength of the walls. If the staves become much thinner they may fail when the silo is full. Well-made monolithic concrete walls need little attention except painting. If the concrete was of poor quality and the silage acids have made it very rough, it may be necessary to scrape and wash the walls thoroughly, and, after soaking them with water, add a coat of rich cement plaster.

It is possible to replace rotted parts of the walls of wood silos, but the better way is to keep the walls painted. Lead paints contaminate silage with poisonous lead and should never be used. Creosoting is probably the most favored treatment for wood walls. Various commercial preparations are also used.

A metal silo should be kept painted from the time it is put up since little can be done once the metal has rusted. Patches may be bolted or riveted over small damaged areas, but it is not likely that a silo so damaged will remain serviceable long. Where corrosion has just started, it can usually be stopped by thorough cleaning and painting. If the silo is leaking where the sheets of metal come together the old bolts can be replaced, a few at a time, and the joints filled with mastic before the bolts are drawn tight.

MONOLITHIC CONCRETE SILOS

Masonry silos—concrete, tile, and brick—are cylindrical. Those of concrete may be of stave, block, or monolithic construction. Tile and brick silos differ mostly in size and shape of units. Because of their weight freight can be a large factor in the cost. However, these materials are manufactured in many sections of the country.

The word "monolithic" means in this case a solid or one-piece wall of concrete. With careful workmanship and a trained crew, a satisfactory silo of medium height can be built with a 4-inch wall, but the ordinary builder will find 6-inch walls easier to build. The same thickness should be continued to the top because of the difficulty of adjusting the forms for a wall decreasing in thickness toward the top.

FORMS

Inner and outer circular forms are needed which can be set up with a 6-inch space between them. Sometimes forms may be rented from the State agricultural college or from a lumberyard, or cost may be cut by cooperating with a neighbor in building them or by buying used forms.

The forms are commonly built 3 feet high, and approximately 33 inches of wall can be built with each setting. They are so constructed that after each course of 33 inches has been placed they can be loosened and raised for another course (fig. 10). In resetting, the forms are allowed to lap about 3 inches over the wall just placed, which helps greatly in getting them into proper position and keeping the walls plumb.

Forms may be of sheet metal or wood, but metal is much better since the forms are lighter than those of wood and they make a smoother wall. Twenty-two-gage black or galvanized sheet iron 36 inches wide may be used. If, however, the diameter of the silo is to be 16 feet or more, sheets 30 inches wide might better be used, because in such cases one course around the silo at the reduced height of wall would make a day's work. Galvanized-iron forms last longer than black-iron forms and, if properly cared for, can be used several seasons for a number of silos of the same diameter.

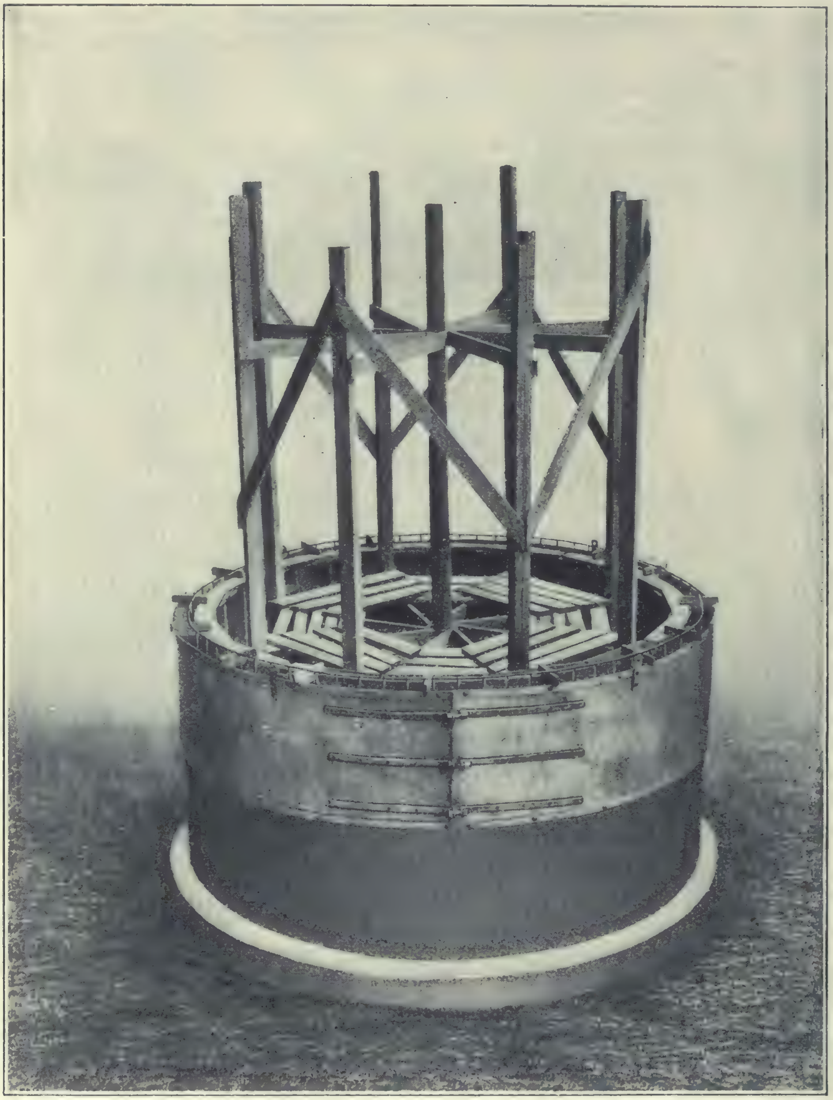


FIGURE 10.—Silo form in position showing the lower part of the wall and scaffold. Note how the scaffold is cross braced.

For the inside form it is necessary to build two supporting circles (figs. 10, 11, and 12) to which the sheet iron or wood, as the case may be, is nailed. These circles are built of 1- by 6-inch material, rough or dressed, of a length depending upon the diameter of the silo, so that 16 pieces will exactly make the circumference. It is not an easy matter to compute the lengths of chords for the various diameters, so they are given below. In figure 11 the chord is the distance from *a* to *b*.

TABLE OF CHORDS

Diameter of silo (feet):	*Chord measurement, feet*	*Chord measurement, inches*	Diameter of silo (feet)—Continued.	*Chord measurement, feet*	*Chord measurement, inches*
10	1	11⅜	15	2	11
11	2	1¾	16	3	1½
12	2	4	17	3	3¾
13	2	6⅜	18	3	6⅛
14	2	8¾	20	3	10¾

LAYING OUT TEMPLETS FOR INSIDE FORMS

Figure 11 shows how to lay out the pieces to be used as templets, or patterns, by which to cut the pieces which, when laid end to end, are to form the supporting circles for the inside form when sheet iron is used. For this part of the work the barn floor or any other large clear space is handy. If no better place is available, a concrete mixing board can be used.

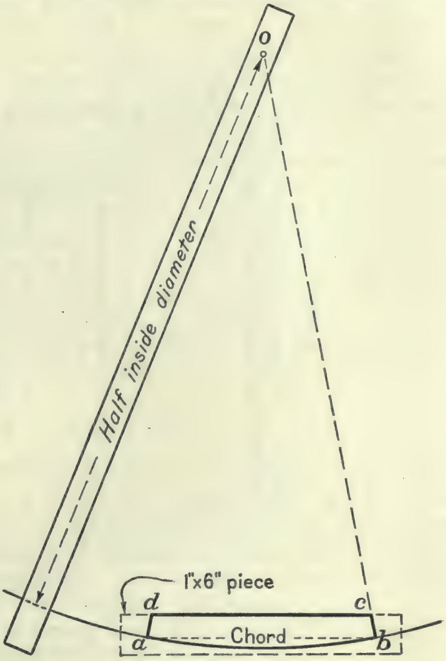


FIGURE 11.—Method of laying out templet.

Select a straight piece of 1- by 3-inch board about a foot longer than half the diameter of the proposed silo, and with a tenpenny nail tack one end to the floor so that the slat will be free to swing about. From this nail, representing the center of the silo, measure on the slat one-half the length of the inside diameter. Here drive a nail until the point extends through far enough to scratch a clear mark on the floor as the slat is swung around on the center *o*, as shown in figure 11. This circle represents the inside face of the wall. An arc equal to one-quarter of the circumference is sufficient. From any point which has been determined to be *a* on the arc, measure the length of the chord in figure 11 as given in the table of chords for the diameter of the proposed silo, and find point *b*. With a straightedge laid through the points *a* and *o*, and also through *b* and *o*, draw short lines on the floor a few inches toward the center from *a* and *b*, respectively. On these lines measure inward 4 inches from points *a* and *b*, and locate points *c* and *d*.

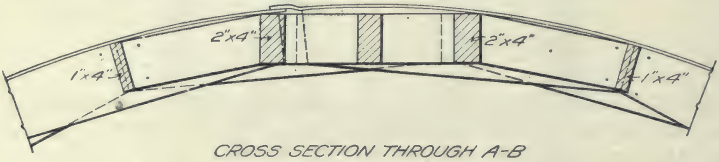
Next take a piece of the 1- by 6-inch board and lay it on the arc with the inside edge flush with points *c* and *d*, as shown in figure 11.

With several small nails tack it to the floor; then lay off the arc again on this piece, and with the straightedge re-mark lines *ad* and *bc*. The piece is now ready to be taken up and sawed. The resulting pattern, or templet, will serve to mark out the 64 pieces necessary to build the two inside circles.

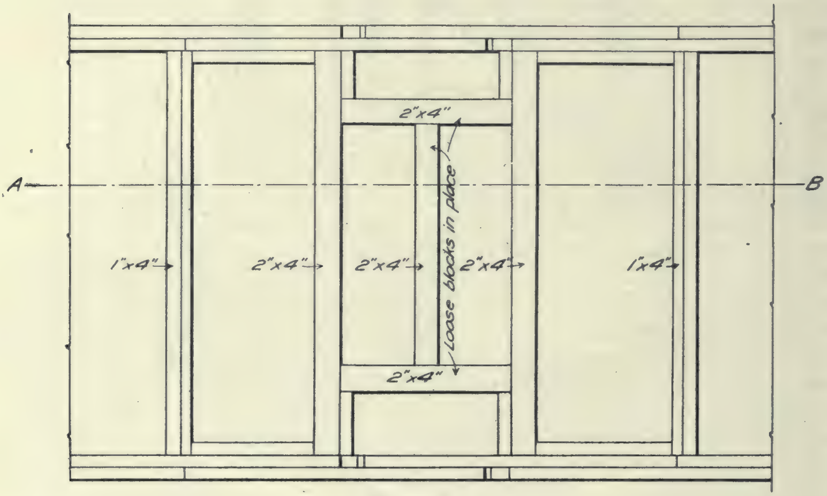
The curved pieces can be sawed by hand, but it is better and cheaper to have the work done at a mill or shop equipped with a band saw.

BUILDING THE CIRCLES

Each of the supporting circles is built two-ply; that is, the pieces are lapped so as to break joints and placed on the circle so that they will fit the curve. Before starting to nail the pieces together, mark out the whole circumference on the floor or on level ground with the slat, as shown in figure 11, and build the circles accurately by laying the pieces flush with the mark. It is important that the circles be well nailed with eightpenny nails driven through and clinched. While the circles are being built, approximate points of division into quarter circles can be marked and those pieces nailed sparingly until after the circle is completed. It is generally safer to build the circles complete and then divide into quarter sections rather than to build



CROSS SECTION THROUGH A-B



ELEVATION

Figure 12.—Part of inside form, showing the method of fitting the form to the wall and holding it in place.

each quarter separately; this division into parts is for convenience in loosening and resetting the forms.

Remove the nails in one-half of every fourth piece in the top layer of each circle. This divides each circle into four equal parts, with lapped joints.

BUILDING THE INSIDE FORM

Three inches should be cut from each end of each quarter section of the circles supporting the forms to allow the sections to slide together when they are to be removed from the wall. Next, temporarily nail the quarter sections together at points of division and brace the top circle directly over and 32 inches above the lower one. See that both circles are perfectly level and that the joints in the upper circle are directly above the joints in the lower circle, and then proceed to nail in securely, between the top and bottom circles, 1- by 4-inch studding, 32 inches long, placing the studs carefully plumbed from 12 to 18 inches apart, as shown in figure 12, to keep the iron from bulging. The end studs in each quarter section should be of 2- by 4-inch material, supported by 1- by 4-inch blocks cut in between the 2- by 4-inch stud and the next 1- by 4-inch stud, and nailed to the circles. Blocks 1 by 4 inches should then be nailed vertically on the opposite side of the 2- by 4-inch studs to hold in place the loose blocks which are used in fitting or releasing the forms from the wall (fig. 12).

Nail the sheet iron on with sixpenny nails, and nail securely, but before beginning to nail the iron on see that it is cut to the proper length. The sheet for each quarter section should be just 3 inches longer than one-quarter of the circumference. If several sheets are required to make a single quarter section, they should be carefully riveted together with a double row of flat-headed rivets. Since the quarter sections lap 3 inches, and in removing need to slide together several inches farther, it is necessary to leave one end of the sheets loose 8 to 10 inches from the end, while the other end should be nailed all the way.

BUILDING THE OUTSIDE FORM

The outside form is made up of four sections of 22-gage black or galvanized iron, each section being 3 inches longer than one-quarter of the outside circumference of the wall, to provide for the lap. The upper edge of each section is reinforced on the outside with a 3/16- by 1¼-inch strap iron securely riveted to the sheet and cut back about 3 inches from each end of the sheet to allow for lapping.

LUGS AND BOLTS FOR OUTSIDE FORM

The quarter sections are joined and drawn together by means of bolts and lugs, the latter made from ⅜-inch tire steel and riveted on the forms, as shown in figure 13; three pairs of lugs bent to the outside circumference of the wall are used at each joint, the lowest pair being placed 2 inches from the lower edge of the form, the upper pair 4 inches from the upper edge of the form, and the third pair halfway between. Note that in one end of the section the lugs are riveted in flush with the edge of the iron, while at the other end they are set in 4 or 5 inches from the edge, to permit a lap. The lugs should be made about 32 inches long, bent up 2 inches at one end, with a ½-inch hole drilled in the bent-up end. The lugs are securely riveted to the sheets with five flatheaded rivets in each strap. For drawing the sections together use ⅜-inch bolts 6 inches long with hexagonal or square heads and nuts and extra-long thread (fig. 13).

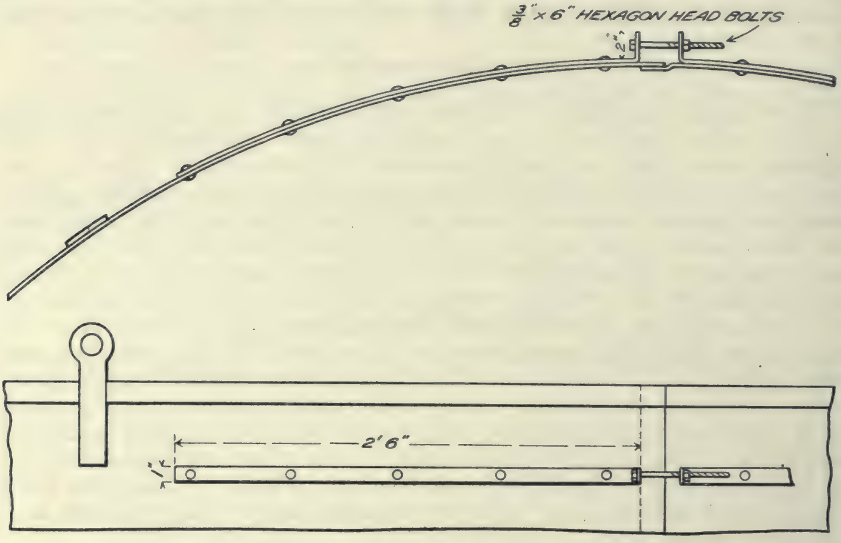


FIGURE 13.—Method of joining sections of outside forms.

Two wrought-steel eyes should be riveted to the upper edge of each section to facilitate the raising of the form.

SETTING THE FORMS

In building the wall the inside form is used from the footing up. Generally for the first 3 feet of wall the outside form is not needed, the earth wall of the pit serving as the outside form. As soon as the wall reaches the top of the ground the outside form must be placed in position. It should be so placed that one of its joints will come on the center line of the door opening. To space the outside form exactly 6 inches from the inner it is good practice to place 6-inch blocks at intervals along the bottom to hold the form temporarily in place. As the concrete is filled in, the blocks must be removed. For spacing the forms at the top a number of pieces of the shape shown in figure 14 will be found useful.

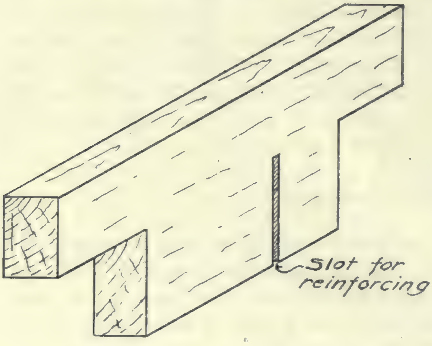


FIGURE 14.—Spacing block.

The greatest care must be taken to have both forms started level across the top and the sides plumb. If on one side of the silo the forms are higher than on the other they are out of round, and consequently the wall at some places will be thicker than at others, thus making it impossible to build the wall plumb. The diligent use of a plumb bob and a good level at each raising will save much annoyance later.

FILLING THE FORMS

The strength, quality, and life of a monolithic concrete wall depend largely on the care used in proportioning, mixing, and placing the concrete. Care must also be taken to have the correct amount of reinforcing placed, as discussed on page 12. Figure 15 shows how carelessness in these matters will cause rapid deterioration in a silo.

Only a few inches in depth of concrete should be deposited at one place at a time; otherwise the forms may be forced out of plumb. As the concrete of a mixture of 1:2:3½ is put into the form it should be spaded with a piece of 1- by 3-inch board, sharpened to a bevel, to remove air bubbles and avoid the formation of cavities. However, the spading must not be overdone, or the heavier aggregate will sink to the bottom, and the cement and water will rise to the top. Only enough water should be used to make a mixture that may be readily worked.

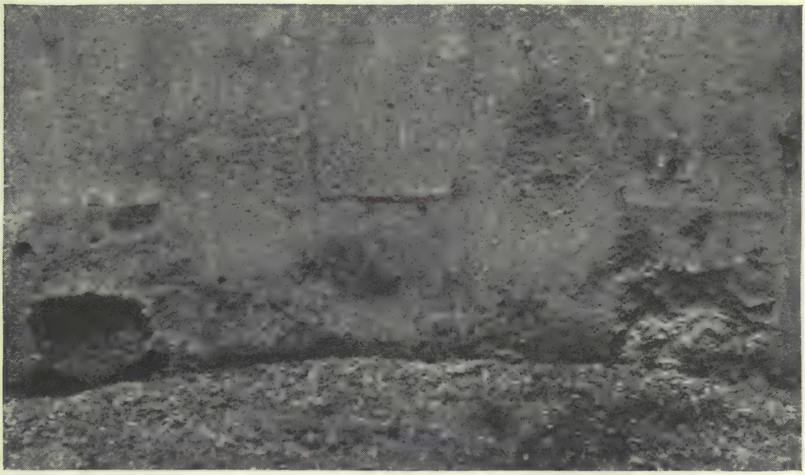


FIGURE 15.—The inside of a concrete silo, showing deterioration of the wall.

Coal scuttles are satisfactory for carrying and pouring the concrete and, if care is taken not to overload them, three will last for the whole job. A rope and single pulley, such as shown in figure 8, may be used for elevating the scuttles.

The exterior surface of the silo can be kept smooth by greasing the outside form at each raising with soap, cheap oil, graphite, or grease. No grease should be used on the inside form, as the inside surface is to receive a brush coat of pure cement wash. Small particles of cement will adhere to this form each time it is raised, and before it is used again they should be removed with a wetted broom or a wooden trowel. If they are not removed, an undue quantity of concrete adheres, making the wall unnecessarily rough.

As the forms are raised the fresh wall is exposed to the air and sun, and there is danger, particularly in summer, of the outside surface drying and curing more rapidly than the inside, thus causing cracks. To prevent this, the outside wall should be soaked with water several times a day for a few days. When possible, it should be protected with canvas or burlap hung from the bottom of the outer form and kept wet.

At the end of the day the top of the concrete is not smoothed, but is left as rough as possible. A good plan is to roughen the top surface just as the concrete begins to set. The next day, before fresh concrete is added, the top surface is soaked with water and then sprinkled with dry cement, which helps make a good bond between courses.

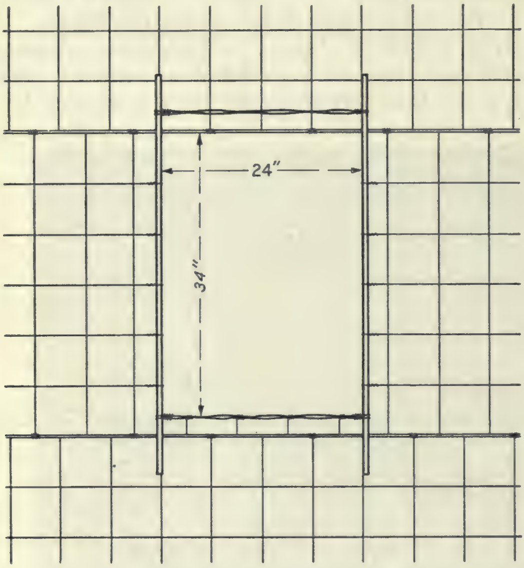


FIGURE 16.—Position of reinforcing around door opening.

At the end of each day's work the mixing board or mixer and all tools should be cleaned; otherwise the next day's work will be more difficult.

RAISING THE FORMS

Before loosening the forms for raising, a straightedge should be laid across their tops and leveled, and marks made on the uprights of the scaffold to show the position of the next set of supporting brackets for the inner form, which will be just 3 inches below the top of the forms. If this is done carefully there will be little trouble in resetting.

Small ropes are attached to the hoisting eyes in the top of the outside form; the bolts in the lugs at the joint of the form which is on the center of the door openings are now loosened sufficiently to permit the release of the form from the wall. By means of the hoisting ropes the form is raised to its new position and clamped temporarily to the wall by means of the lower lugs, or held suspended by the hoisting ropes attached to brackets from the scaffold. The reinforcement is set for the next course and laced to the reinforcement of the preceding course. Next, the loose key blocks of the inside form are removed and the form lifted by sections and placed temporarily on top of the wall. The supporting brackets are nailed in place and the working platform relaid. This done, the sections of the inside form are set in place on the brackets and the form clamped against the wall by replacing the loose blocks; the blocks should be marked for identification or fastened to the form so they will not be lost or interchanged.

Both sets of forms should now be plumbed and leveled, the outside form clamped in place, and spacing blocks inserted between the forms in sufficient numbers to hold the outside form to a true circle.

Care should be taken to avoid jarring the wall by heavy pounding, which is likely to injure the green concrete in the process of setting. The forms should not be removed until the concrete has set sufficiently. A good working plan is to raise and fill the forms in the morning and then leave them undisturbed until the next morning.

DOORS AND DOORWAYS

Special care must be taken to have the reinforcing around the doors as strong as in any other part of the wall. Figure 16 shows how a ⅝-inch rod, or its equivalent, should be placed on each side of the opening about 2 inches from the door form. The horizontal strands of the reinforcing are cut to admit the door form, and the ends are securely wound around the iron rods; the rods should extend 6 or 8 inches above and below the door openings and should be tied together with several strands of No. 8 or No. 9 wire.

On account of the greater ease with which the silage can be removed, many prefer a continuous door opening. A continuous doorway can be made by setting 1-inch pipes vertically spaced at such a distance as to allow 4 inches of concrete between the pipe and the edge of the door opening. These pipes should extend about 1 foot into the foundation. The reinforcing wire is fastened securely to them, and ⅞-inch rods extending horizontally across the doorway are hooked around the pipes every 20 inches. These rods serve the purpose of preventing the doorjambs from spreading and carry the strain of the reinforcement across the door opening (fig. 17). They also form the rungs of a ladder for the silo.

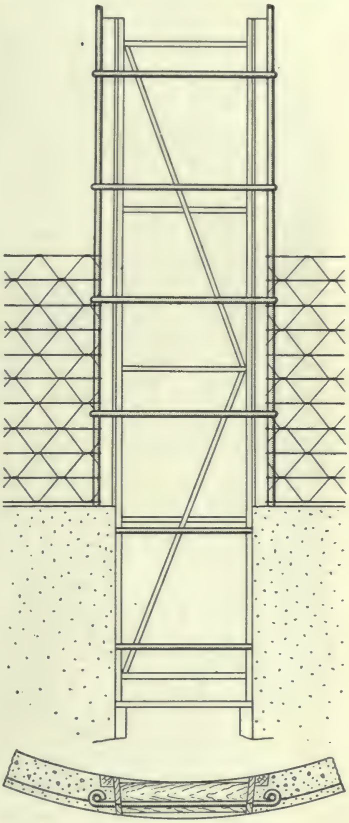


FIGURE 17.—Details of forming and reinforcing a continuous doorway.

The door itself may consist of 2-inch Select planking 10 or 12 inches wide, cut in 2-foot lengths, or a door may be made by nailing together two thicknesses of 1-inch boards with building paper between them (fig. 18, *b*). These planks or doors fit into a rabbet on the inside edge of the doorway. This rabbet is formed in the concrete by the use of a form to which are attached 2- by 2-inch strips, as shown in figure 17.

After the reinforcement around the door opening has been arranged, as shown in figure 16, a form for the making of the door opening should be set in between the wall forms. This form is built of such size and shape (fig. 18) that when the concrete is molded about it a 2-inch rabbet is formed around the inside of the opening into which a wooden door can be set, this door being held in place by the pressure of the silage on the inside. The piece (fig. 18) which forms the rabbet at the bottom of the door opening should be left loose so that the concrete can be filled to the bottom of the door opening. In order that the form may be easily removed without injury to the wall, the top and sides are built with a slight taper, which permits the form to slip inward when lightly tapped on the outside. The bottom pieces or sill of the form should be left flat. All the surfaces should be dressed with a plane and greased before using. In placing the concrete about the form, considerable care must be taken to have it well worked in under the sill, or a rough job will be the result. The sills of the doors, especially of the bottom door, receive much wear, and should be protected by a piece of angle or strap iron, which is inserted at the time the rabbet piece is placed.

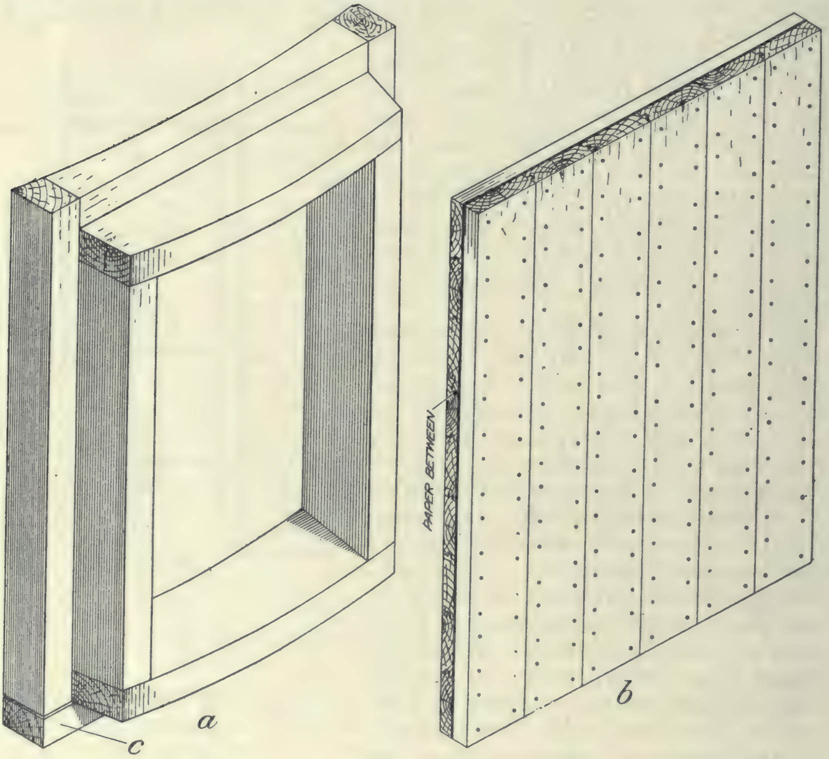


FIGURE 18.—Silo door and form for intermittent door openings.

Unless it happens that the position of the doors exactly coincides with the alternate raising of the wall forms, two forms will be required. The top and bottom pieces of the forms are curved to the circumference of the silo and should be marked off with the slat shown in figure 6 in the same manner as the templet.

CONCRETE-STAVE SILO

Concrete staves for silo walls are available in many parts of the country. They are generally 10 inches wide, 30 inches long, and 2½ inches thick. They are bound together with hoops, the joints sealed with cement plaster and the surface finished as noted on page 15. The size and spacing of the hoops are given in table 9. In the purchase of staves for such a silo (fig. 19) a guarantee should be obtained from the manufacturer that they will meet the requirements of the American Concrete Institute. In a silo higher than provided for in the tables in this bulletin it may be necessary to use thicker staves to give adequate safety against crushing. If a silo of unusual height is contemplated, a competent engineer should be employed to design the walls and foundation to take care of the excessive wall loads due to silage and wind pressure. Many manufacturers of concrete staves quote prices on a silo set up on the farm, and often this is the most economical way to buy.

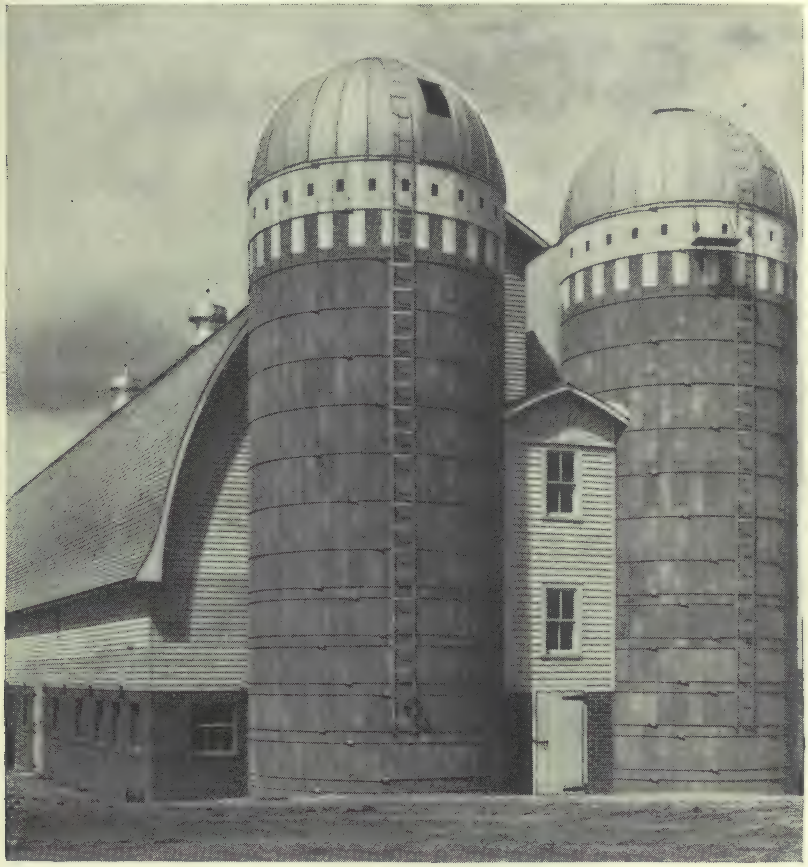


FIGURE 19.—Concrete stave silo.

Precast concrete doorframes are generally most satisfactory for this type of silo. The chute usually requires seven or eight staves from silo wall to silo wall, is supported on an iron bracket, and is bound to the silo with supplementary hoops, as shown in figure 20.

CONCRETE-BLOCK SILOS

Under some conditions concrete blocks are most economical and make a lasting and desirable silo (fig. 21). There are several different kinds of concrete blocks in use, such as straight or curved solid blocks, with or without reinforcing, two-piece blocks, and straight or curved blocks with air spaces and with the top bed grooved to receive the reinforcing. The usual size of block is 8 by 8 by 16 inches. If blocks have to be shipped any great distance, the cost is likely to be prohibitive.

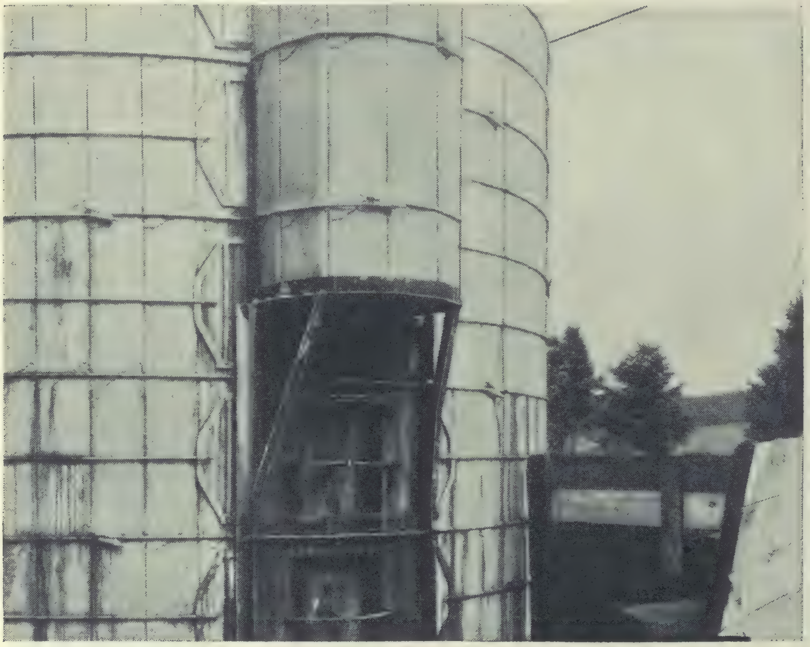


FIGURE 20.—Method of supporting a stave chute. Note how the intermediate hoops are carried across the doorway by iron straps spread to give unobstructed openings.

In building a block silo, care must be taken to have sufficient reinforcing, sound blocks, and good mortar joints. If the joints are not waterproof, leakage will occur, causing spoilage of the silage next to the walls, and the silage juices will cause rapid corrosion and failure of the reinforcing.

When block walls are started the blocks should first be laid around the footing in a true circle, beginning at the doorway with a full block and ending at the opposite side of the doorway with a half block. All mortar joints should be of equal thickness. The blocks are then bedded in place in mortar. The amount of reinforcing indicated in table 8 should be placed (fig. 22) between courses as they are laid up, care being taken to break the joints by one-half block, keeping each course directly above the former course in a true circle and the face of the wall plumb. Mortar should be made of 1 part cement and 2 parts sharp clean sand, with not more than 10 percent as much lime as cement added to make it workable.

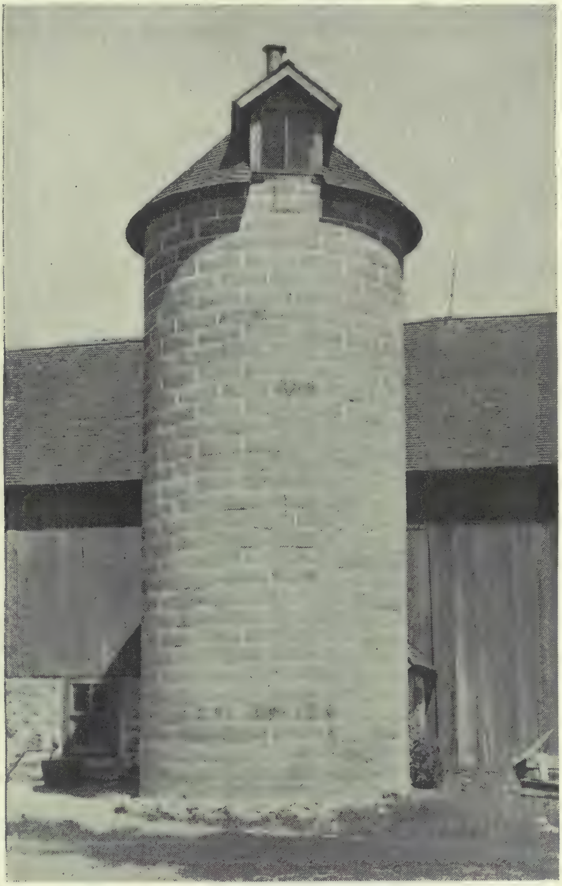


FIGURE 21.—Concrete block silo.

The chute may be made of wood, metal, or concrete blocks. A wooden chute (fig. 31) is fastened to the silo by means of 2- by 4-inch pieces bolted in place along each side of the doorway with bolts set in the concrete of a continuous doorframe or in the mortar joints between courses. A metal chute is bolted on in the same way. In a block chute the blocks can be bound to the wall by blocks or with metal ties and either run down to the floor level or supported by an I-beam level with the plate of the feed room.

TILE SILOS [2]

Tile silos (fig. 23) are built of hard burned or glazed tile especially molded to fit the curve of the wall. When well-constructed of sound tile, they are very durable and require little upkeep. The doorway is generally continuous, and the jambs are usually built of poured concrete or of special jamb blocks. The special blocks have a 2-inch rabbet along the inside edge to receive the doors. Vertical reinforcing is placed through openings in the jamb blocks and the horizontal rods, used in quantities given in table 8, are attached to the vertical ones. All these reinforcing rods must be well imbedded in mortar. The wall should be laid out and built up as described under concrete block silos. All reinforcing must be covered with mortar and the joints well filled to make the silo waterproof and to protect the reinforcing iron from corrosion. The manufacturers of silo tile furnish construction directions, and some of them will contract to build the silo. Chutes can be built like those in concrete-block silos.

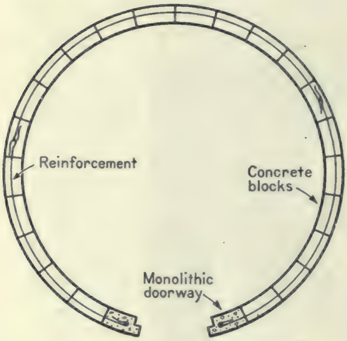


FIGURE 22.—Method of placing reinforcing between courses. Note how the rods are anchored to the vertical reinforcing at the doorway.

BRICK SILOS

Good hard-burned brick are suitable for silos if they can be obtained at a reasonable cost and laying is not too expensive. Cull paving brick have been used in many instances to good advantage. These silos are built with either single or double walls. The single wall 4 inches thick is the most common since it requires less material and labor.

Manufactured doorframes, ladder rungs, and bolts to go with fabricated reinforcing bands can be purchased. The fabricated reinforcing is in the form of flat corrugated bands curved to fit the size of silo desired. If such reinforcing is not available rods or wire can be used in the amounts recommended in table 8. The reinforcing is placed between courses, spaced to give the necessary strength. When a high silo is built and the reinforcing required per foot of height is large, it is better to use smaller wire or rods in each course or in alternate courses than to increase the size of the mortar joints to care for heavy reinforcing.

Chutes made of brick are most desirable. They are bonded to the silo wall with metal ties or brick and supported on steel I-beams. Metal or wood chutes may also be used, such as those described under concrete-block silos. Detailed instructions for building brick silos may be obtained from the Brick Manufacturers Association, Cleveland, Ohio.

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[2] A detailed description of the construction of tile silos and specifications for the blocks can be found in Iowa Station Bulletin 189, Silo Construction, obtainable from the Department of Agricultural Engineering, Iowa State College, Ames, Iowa, for 6 cents.

WOOD-STAVE SILOS

Of the various woods available, redwood, cypress, longleaf pine, white pine, cedar, and Douglas fir are generally considered best for silo staves. The wood should be creosoted before being used.

TYPES OF STAVES

Wood-stave silos are generally built of milled tongue-and-groove staves. This type is undoubtedly the most satisfactory, although many silos built with square- or slightly bevel-edged staves have also given satisfaction. Where good, well-seasoned 2- by 4-inch or 2- by 6-inch lumber is available at low cost the square-edged stave silo can be erected at a lower first cost than most other types. They are erected like other stave silos except that the staves are nailed together every 4 or 6 feet as illustrated in figure 24.

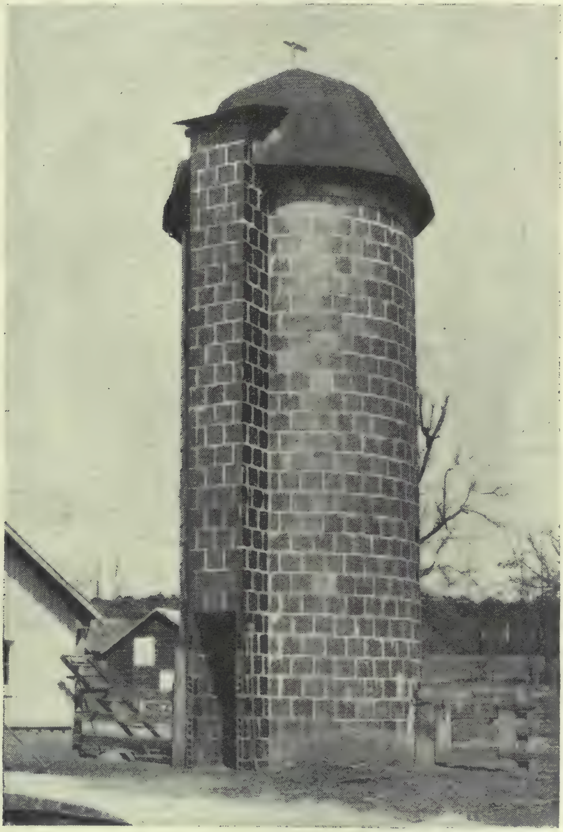

FIGURE 23.—Tile silo with tile chute.

Tongue-and-groove stave silos are generally purchased as a complete unit including staves, hoops, doors, roof, and anchoring materials. Care should be taken to see that the staves are of good quality and that sufficient hoops (table 9) are furnished.

The silo should be bolted to anchors set in the foundation (fig. 3), from four to nine anchors being used depending on its size. Where high winds are likely, additional anchorage should be provided, with cables fastened to the top of the silo and run to anchors in the foundation or to anchors set a few feet away from the foundation. Where the silo is built close to the barn two or three such anchors will suffice.

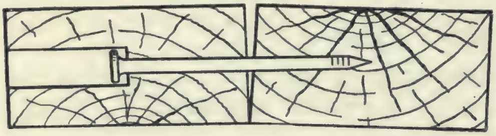

FIGURE 24.—Spiking staves together.

It is preferable that each stave be in one piece, but if this is impossible, the staves should be of two pieces of different lengths, splined together by making in the ends to be joined a saw cut 1 inch deep and parallel to the sides of the stave and inserting a galvanized sheet-iron spline, as shown in figure 25.

CUTTING THE DOOR STAVES

Before the staves are put up it is necessary to decide how many doors the silo should have and make saw cuts halfway through one of the staves to be put up in the doorway location for the entrance of a handsaw in cutting out the doors after the staves are in place. The cuts should be made at a slant of 45° on the edge of the stave and horizontal on the front, as shown in figure 26, so as to make the doors removable only toward the inside. The cut for the bottom of each door should slant downward from the outside of the stave, and that for the top should slant upward.

To prevent this stave from being broken in handling, a slat should be nailed on one side of it. This slat should be removed after the stave has been put in position.

When the staves are being put up, the partly cut door stave should be placed at one side of the place where the doors are to be cut. The doors are sawed out after the hoops are put on.

SETTING UP THE STAVES

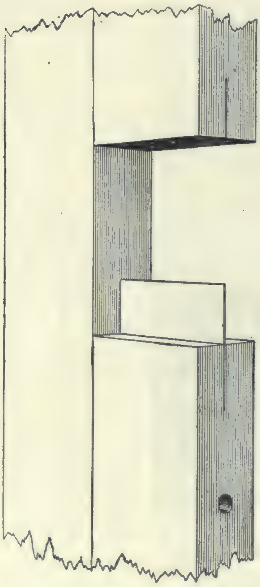

FIGURE 25.—Splicing wood staves.

The first stave should be placed with its inner face on a line drawn on the foundation wall 2 inches from its inside edge, plumbed on the face and edge, and securely braced at top and bottom. Braces are nailed to stakes driven firmly into the ground or to some adjacent building, as shown in figure 27. If this is not carefully done the silo will be out of plumb.

In setting up spliced staves the longer and shorter staves should alternate. Ordinarily it will be necessary to have staves of only two lengths, for instance, 16 feet and 12 feet for a 28-foot silo. When all the hoops are in position they should be tightened until the staves are pressed close together. Staples should then be driven over each hoop 2 or 3 feet apart to hold them up in case they get loose.

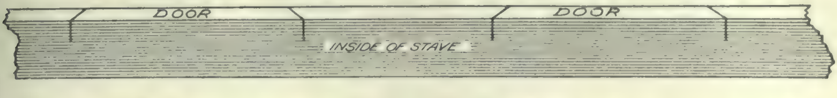

FIGURE 26.—First stave with door cut started to allow the entrance of a saw when set up.

Care must be taken to tighten the hoops of a stave silo to prevent storm damage or collapse as the staves dry out when the silo is empty.

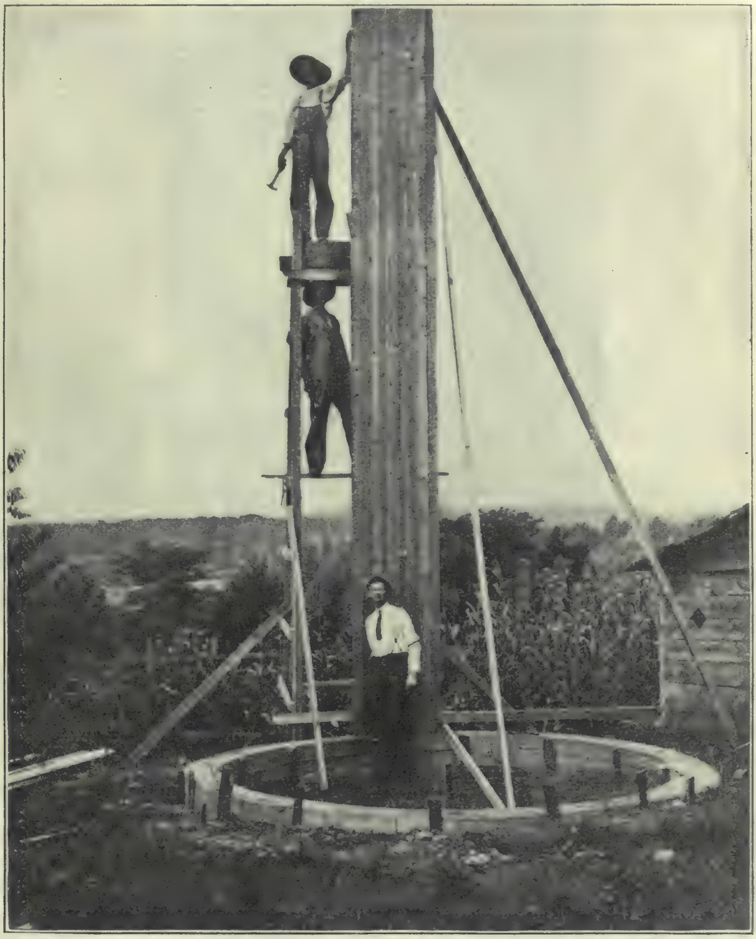

FIGURE 27.—Setting up the staves.

They should be loosened as the silo is filled to prevent crushing as the staves swell from absorbed moisture.

JOINING HOOPS WITHOUT LUGS

It is sometimes very difficult to get lugs for the hoops. In such cases 4- by 6-inch timbers may be put in instead of ordinary staves at from two to four points where the hoop sections will join. These timbers should be placed with the 4-inch face flush with the staves on the inside. They will extend 4 inches beyond the wall on the outside. Through these outside projections holes should be bored to receive the hoops, and the ends may be fastened with nuts over large iron washers. Such a method of connecting hoops is shown in figure 28, but its use is advised only when the lugs cannot be obtained.

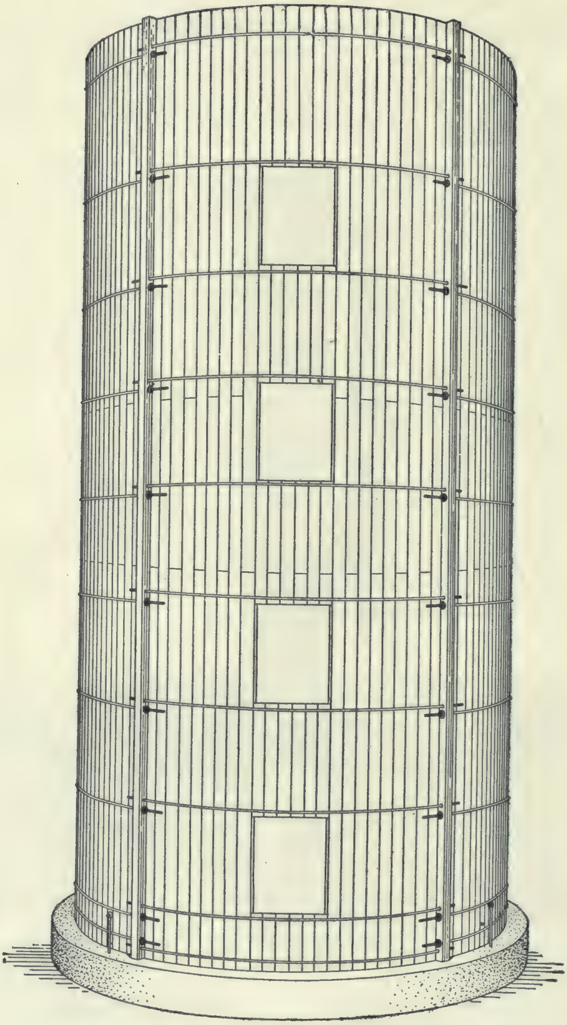

FIGURE 28.—Joining hoops without lugs.

DOORS AND DOORWAYS

After all the hoops are tightened, saw the doors out, beginning with the stave previously cut. Two cleats, 2 by 4 inches, with one edge cut to the circle of the silo, should be nailed and bolted on the outside of each door (fig. 29) with the nuts on the outside and the bolt heads sunk flush with the inner surface. The bolts should be ⅜ by 5 inches.

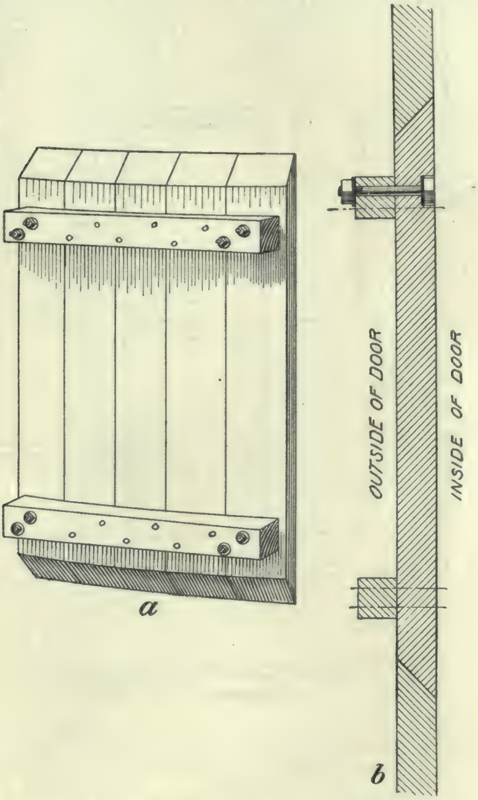

FIGURE 29.—The finished door: *a*, Door showing outer surface and cleats; *b*, section of wall showing how door fits.

Four bolts in each cleat (two at each end) will be sufficient. The cleats may be nailed to the other strips.

To construct a continuous doorway for a stave silo, a frame should be made of 4- by 6-inch timbers, which are kept 20 inches apart by means of pieces of pipe and fastened together with bolts passing through the posts and pipes, as shown in figure 30. The holes for the spacer bolts should be drilled through the doorposts with the same vertical distance between them as the hoops are to have. The hoops should cross the door opening not more than 2 or 3 inches from the spacers so as not to obstruct the door opening. Iron washers should be placed between the timbers and ends of the pipe. Washers should also be used under the bolt heads and nuts.

When the doorframe is complete, it should be put in position, plumbed, and securely braced, after which the staves should be put up, as previously described. The doorposts should be flush with the staves on the inside. On the outside they will project beyond the staves, and holes for the hoops should be bored in these projections.

Doors for this frame are made of two thicknesses of tongue-and-groove flooring with acidproof building paper between, the inside flooring running vertically and the outside horizontally. The doors may be held in position by means of iron straps, one on each side, which projects over a slat nailed to the doorpost. When the silage is to be used, the topmost door is taken out, which makes room for sliding up the other doors as the silage is fed out. The doors may be held up by pins placed in holes in the posts.

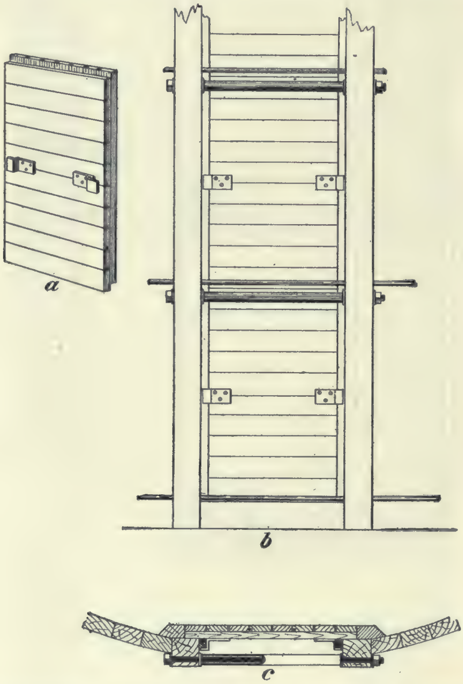

FIGURE 30.—A continuous doorway: *a*, View of door; *b*, doorframe with door in position; *c*, cross section showing door and doorframe.

As shown in figure 30, the doors are so made as to overlap where they meet and thus make a tight joint.

CHUTE

A chute is built over the doors, as shown in figure 31. The simple 2- by 4-inch framing is merely spiked to the staves. Where the silo has intermittent doors a ladder is built on one side of the chute.

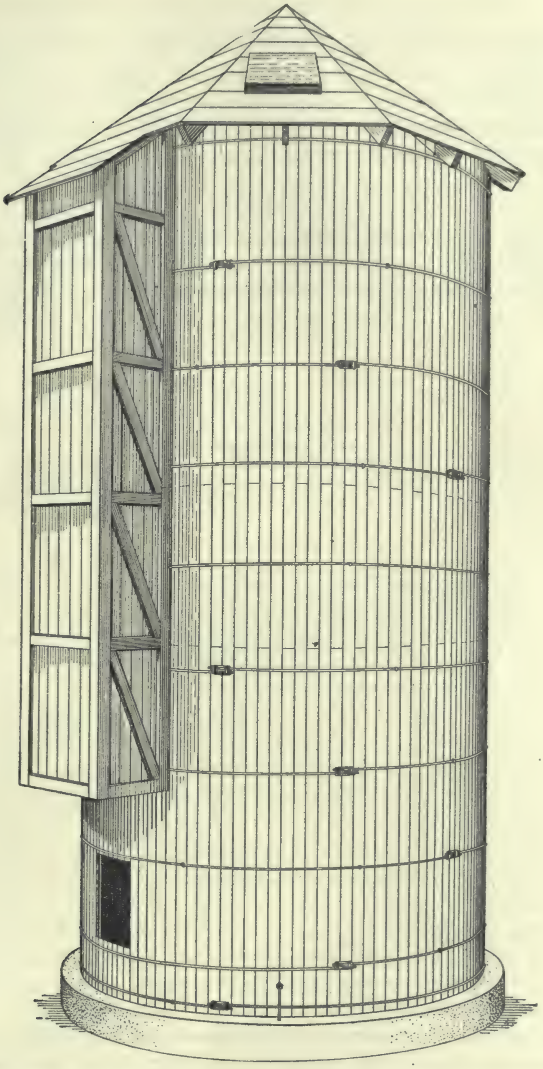

FIGURE 31.—Complete stave silo with chute.

THE MODIFIED WISCONSIN SILO

REQUIRES NO METAL REINFORCING

The modified Wisconsin silo, built of studs and horizontal sheathing, requires no metal reinforcing. The ½-inch sheathing is bent to the circle formed by 2- by 4-inch studs, spaced 1 foot on centers, and acts as a hoop to resist the silage pressures. Rough lumber of random lengths can be used for this type of silo, which makes possible low-cost construction in regions where local lumber is available.

FOUNDATION

The foundation for the modified Wisconsin silo is constructed the same as that for a stave silo. Instead of eyebolts, anchor bolts 16 inches long should be used. These should be embedded in the foundation wall 5 to 6 feet apart and 3 inches from the inside edge, extending 5 inches above the top of the wall.

SILLS AND PLATES

The sills and plates are formed of two thickness of 2- by 4-inch pieces, 2 feet long, with the ends beveled to form a circle. The proper bevel may be determined in the following manner: From the center stake used in laying out the foundation wall draw a circle on top of the foundation wall 1 inch from the inside edge (fig. 32). At any point on this line lay a 2- by 4-inch piece 2 feet long, with both ends at equal distances from the center; then use a slat with one edge on the center point of the stake and let the same edge on the other end of the slat strike the outer corner of the 2- by 4-inch piece. A line drawn along the slat across the 2- by 4-inch piece will give the proper angle or the bevel. The same process will give the bevel for the other end.

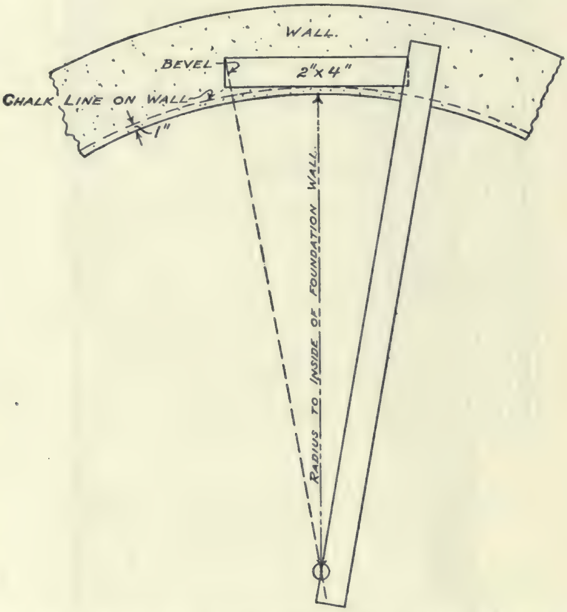

FIGURE 32.—Method of obtaining bevel ends for sill and plate.

Use this piece as a pattern in cutting pieces enough to form the double circle for both sill and plate. The number needed will depend on the diameter of the silo. After cutting several pieces, lay them along the wall, note how they fit, and make any necessary changes. When all the pieces are cut lay them out on the wall along the line 1 inch from the inside edge of the wall, boring the necessary holes for the anchor bolts. On this layer place the second course, breaking the joints, and boring the holes. Next cut the same number and size of pieces to be used for the top plate and lay aside until needed. Then spike the two rings of the sill together and tighten the nuts on the anchor bolts.

DOORPOSTS

It is preferable to set the doorposts before the studs are placed, so as to avoid trouble in getting the door in just the right place. The doorposts should be 4 by 4 inches and long enough for the height of the silo. If not, they may be spliced by halving and bolting (fig. 33). Set them up to the line 1 inch from the inside edge of the foundation wall, leaving a 24-inch space between. Toenail securely to the sill. The openings for the doors are made by nailing in headers and sills at the places where the doors are desired, leaving the spaces open when the inside sheathing is put on. For the size of the openings, see figure 34.

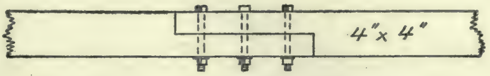

FIGURE 33.—Splicing doorposts.

STUDDING

The size of the studding is 2 by 4 inches, and if the pieces are not long enough for the height of the silo they can be spliced with 1- by 4-inch pieces 4 feet long, nailed on each side over the joint (fig. 35). Whenever it is necessary to splice the studs the pieces should be of different lengths, such as 12 feet and 16 feet for a 28-foot silo, and in setting the studding the long and short pieces should alternate.

It is preferable to do the splicing before the studs are placed in position. When all are spliced and cut to equal length they should be placed 1 foot apart from center to center, with the edge 1 inch from the inner edge of the foundation wall, or in line with the circle previously marked out in laying the sill, and then toenailed to the sill. Great care should be taken to have the studs plumb on all sides and well braced to the inside scaffold so that the top of the silo will form a circle. The pieces to form the plate can be nailed on as the studs are set, laid in the same way as the sill, and nailed firmly to the tops of the studs.

At least two hoops formed from the thin sheathing should be nailed around the outside of the studding to keep them from bulging while the sheathing is being nailed on. These hoops can be removed after the sheathing has been placed on the inside.

SHEATHING

The sheathing, of ½- by 6-inch material, is put on from the bottom up. To prevent uneven bending, the joints should come on different studs. At the door openings the lining is cut back 1 inch from the inside edges of doorposts to form a rabbet for the doors (fig. 34).

Two layers of the sheathing are put on the inside with acidproof building paper between (fig. 34). The lining will be stronger if the cracks and joints in the first layer do not come opposite those of the second. It is more convenient if these two layers are carried up with the one on the studs just far enough ahead of the others to give room for putting on the paper.

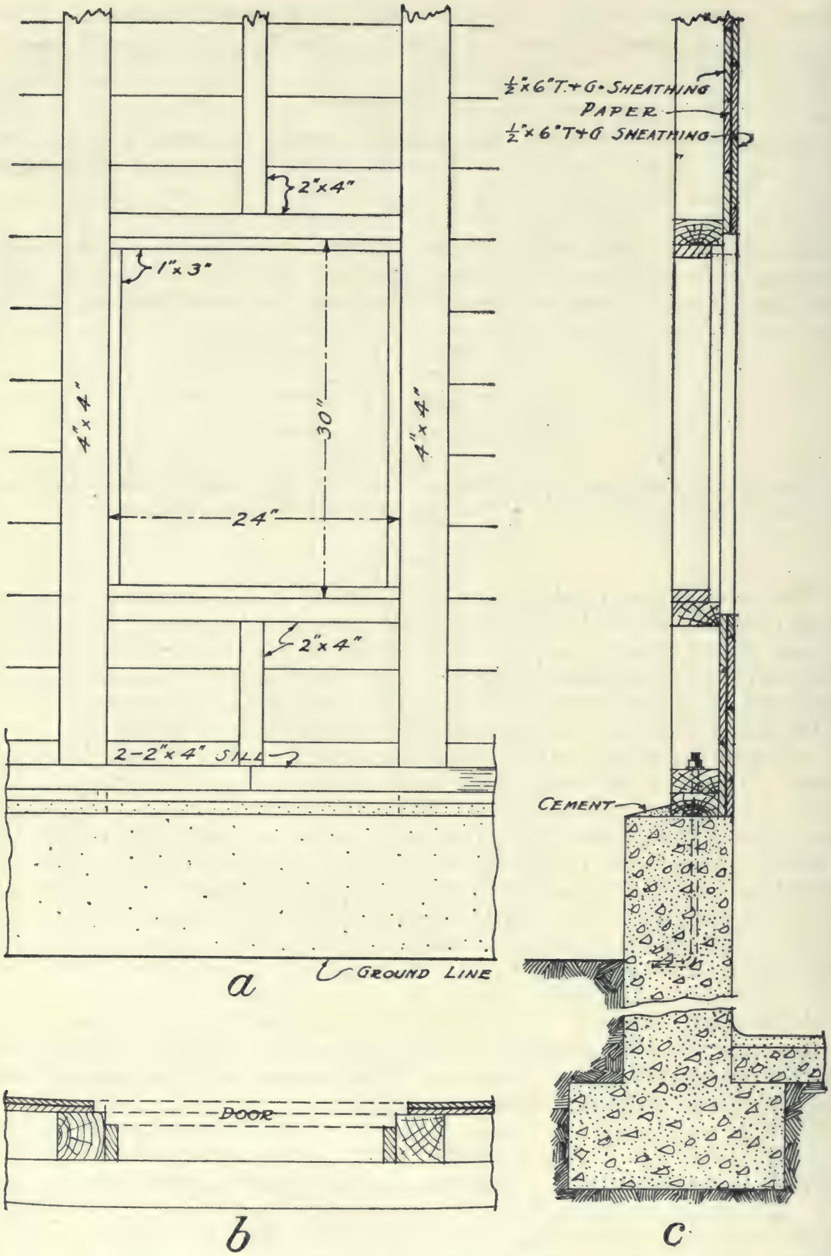
½"x6" T.+G. SHEATHING
PAPER
½"x6" T+G SHEATHING
2"x4"
1"x3"
4"x4"
30"
24"
4"x4"
2"x4"
2-2"x4" SILL
CEMENT
GROUND LINE
a
DOOR
b
c

FIGURE 34.—Details of construction of modified Wisconsin silo: *a* and *b*, details of door opening; *c*, sectional view of foundation and wall.

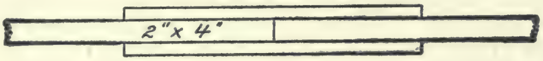

FIGURE 35.—Splicing studs.

DOORS

The doors are made of two thicknesses of 1- by 6-inch tongue-and-groove flooring, the inside layer vertical and the outside horizontal, with acidproof building paper between (fig. 36). A 1- by 3-inch strip is then nailed around the door openings 1 inch from the inside of the studs to form the jambs.

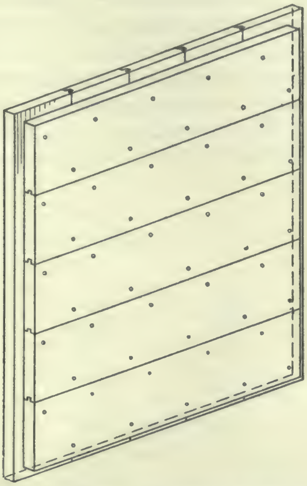

Figure 36.—Door for modified Wisconsin silo.

THE WOODEN-HOOP SILO

THIN BOARD HOOPS AND SHEATHING USED

The wooden-hoop silo is made with hoops of thin boards lined with tongue-and-groove sheathing placed inside the hoops and, often, with moisture-resistant paper between. This sheathing may be 1 or 2 inches thick, preferably 2 inches. Short lengths of milled staves are often used, shorter than can be used in regular stave silos.

ANCHORAGE

Four to six anchors, of ⅜- by 1½-inch strap iron 46 inches long, with the lower ends bent out 2 inches, should be imbedded in the foundation wall. Two holes for half-inch bolts should be drilled in these irons, one 2 inches and the other 24 inches from the upper end. The anchor irons (figs. 3 and 38) should be placed in the foundation wall 2¾ inches farther from the center of the silo than the inside of the silo wall, with the lower hole 4 inches above the foundation, so they can be bolted through the two lower hoops to the silo wall.

BUILDING THE FORM FOR HOOPS

The hoops are made on a form. First, drive a 2- by 4-inch stake and saw it off 1 foot from the ground. Fasten one end of a strip a few inches longer than the radius of the proposed silo to the top of this stake with a tenpenny nail. Measure from the nail 1 inch longer than the radius of the silo, and cut the strip off at this point. One inch toward the center from the outer end of the strip, drive a 1- by 4-inch stake about 20 inches long, swing the strip halfway around the circle and drive a similar stake in line with the first and the center stake; swing the strip quarterway around and drive a third stake, and place a fourth stake opposite the third stake. Drive additional stakes (fig. 37) around the circumference so that the spaces between stakes are about 2 feet. Fasten to these stakes 2- by 4-inch uprights about 6 feet long, with their outer edges plumb and flush with the end of the measuring strip. When all the uprights are in place remove the measuring strip. Tie opposite uprights at the bottom with 1- by 1-inch strips of edging material cut to the exact diameter of the form, which is the same as the outside diameter of the silo wall. These strips should be marked in the middle, the lowest one nailed at this point to the top of the center stake and the remainder nailed to each other at these marks. Beginning about 4 feet from the ground, tie the upper parts of the uprights in the same way. The uprights should be plumbed and braced to each other, and about four braces should be run from the uprights to the center stake.

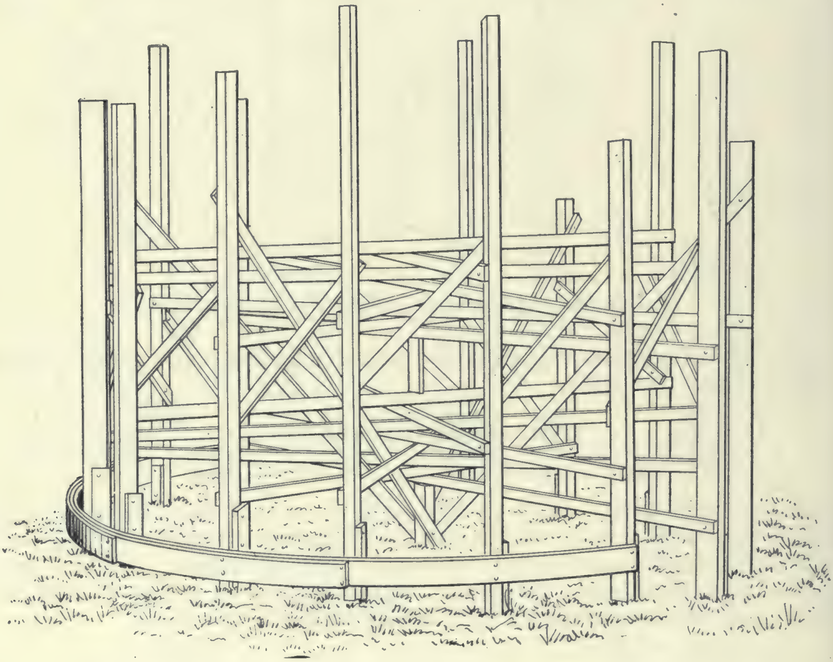

FIGURE 37.—Form for building hoops for wooden-hoop silo.

MAKING THE HOOPS

The hoops are made of 4-inch oak, elm, ash, pine, or chestnut strips ½ inch thick or a trifle thinner. They are usually made three-ply, except for silos of the larger heights and diameters, for which four-ply hoops are used. Make a mark on the outside face of one of the uprights about 6 inches above the ground. Level around from this mark with a carpenter's level, marking each upright. The marks indicate the position of the upper edge of the first hoop. Now fasten one end of the hoop material (fig. 37) to one of the uprights, so that it will bend around the form to the left; nail it to each upright with the upper edge flush with the mark. At the third upright begin the second ply of the hoop, at the sixth the third ply, and bend the boards around the form, nailing to each upright with eightpenny nails, and between the uprights and at the joints with sixpenny nails. Break the joints. Butt joints in the outer layer should be carefully fitted. Start the second hoop on the next stud to the left of the place where the first hoop was started, and continue as before. The number of hoops required is one-half the height of the silo, in feet, plus 1. Thus, a 30-foot silo requires 16 hoops.

When all the hoops are completed they are numbered from the bottom up, and perpendicular lines are drawn in four places to assist n plumbing the hoops when raised in position. The form is now torn out and all nails in the hoops clinched. All joints in the outside layer of each hoop should be covered with pieces of galvanized iron 12 inches long, nailed with galvanized brads, to protect the joints from the weather. The hoops are next placed on the foundation in the same order and position as on the form, with one of the perpendicular lines immediately on the left of the proposed door opening. The scaffold is now erected so that the hoops may be placed in position.

SPACING THE HOOPS

On the ground splice four staves, each equal to the height of the silo, and mark on them the spacing of the hoops. The mark for the first hoop should be 6 inches from the bottom of the stave, the next three marks are spaced 23 inches, and the remainder 24 inches, except the last two, which are spaced 23 inches. These staves are now placed n position on the foundation, each one flush with one of the perpendicular lines drawn on the hoop, and are nailed temporarily to the bottom hoop. The top hoop is now raised with ropes and nailed in position to the tops of the spacing staves and supported by 2- by 4-inch pieces attached to the scaffold. The remaining hoops are raised and fastened to the spacing staves in their proper positions. The hoops are then plumbed at the spacing staves, starting on the left of the proposed door opening, and braced to the scaffold.

PLACING THE STAVES

The first stave is carefully plumbed and nailed on at the left of the door opening. Nail the staves on as flooring is laid (fig. 38), driving the tongue into the groove and blind nailing, to each hoop with two nails. Break the joints in adjoining staves, and make all joints on hoops. Plumb the edge of the staves about every 5 feet around the wall, and continue nailing the staves on until the opposite side of the door opening is reached. The temporary spacing staves are removed as the sheathing of the wall progresses to them. The opening left should be about 35 inches wide to allow for fitting in the doorjambs and doors 24 inches wide. Bolt the silo to the foundation (fig. 38), running ½- by 3¼-inch bolts through the staves, hoops, and anchor irons.

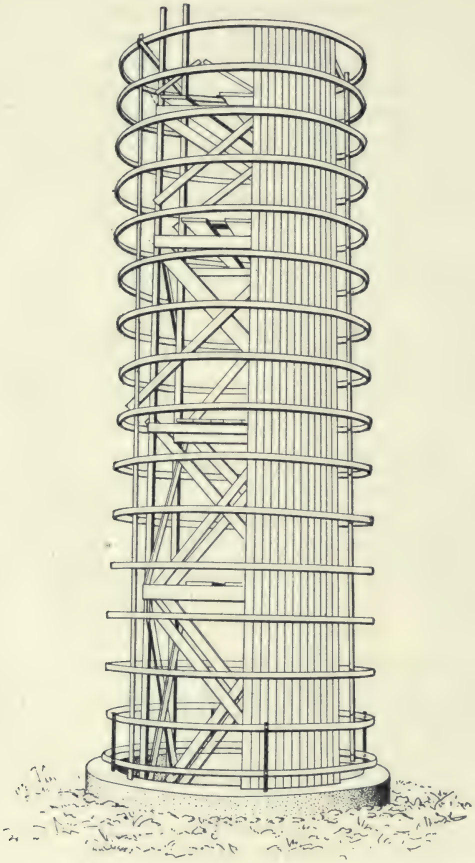

FIGURE 38.—Wooden-hoop silo started with scaffolding, hoops and several staves in place.

DOORJAMBS

Cut pieces of 1- by 4-inch lumber 35 inches long, bevel the ends to fit the inside curve of the hoops, and nail the ends of one of these pieces across the opening on the inside of the upper hoop and one on the inside of the lower hoop. The remaining pieces are similarly fitted and placed in position on the hoops, carefully plumbed and nailed into place (fig. 39). These pieces form stops for the tops and bottoms of the doors. After these crosspieces are in place, nail an additional stave on each side of the opening. Next prepare two other staves for doorjambs by removing the tongue from one of them and the groove from the other and fasten them into place on each side

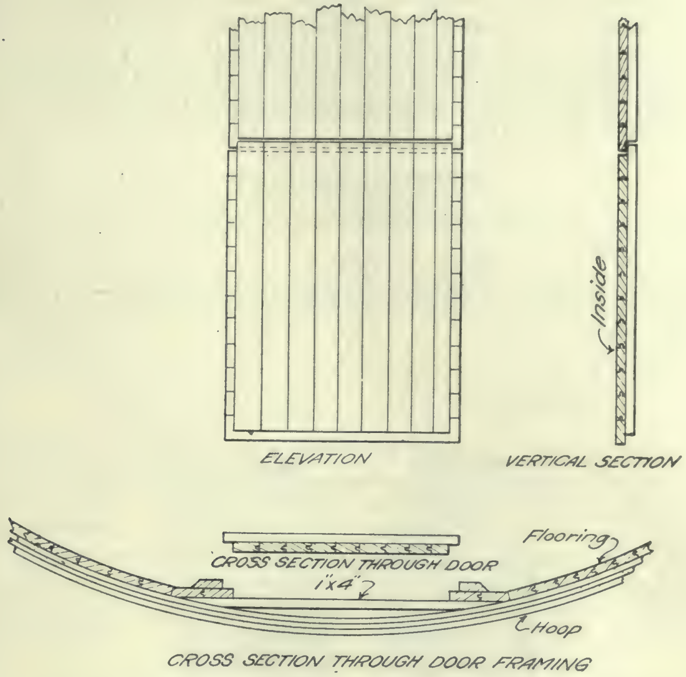
ELEVATION
Inside
VERTICAL SECTION
Flooring
CROSS SECTION THROUGH DOOR
1"x4"
Hoop
CROSS SECTION THROUGH DOOR FRAMING

FIGURE 39.—Details of door and doorway for wooden-hoop silo.

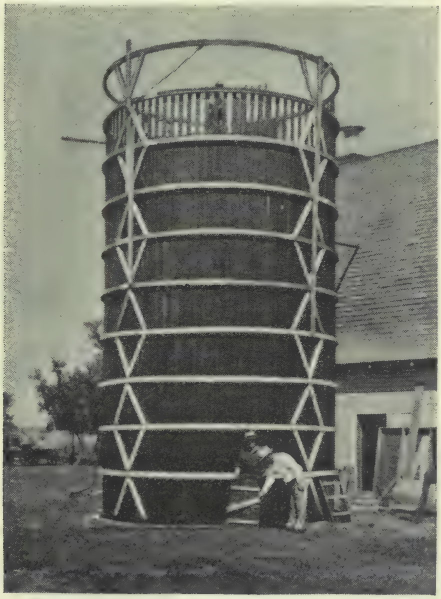

FIGURE 40.—Wooden-hoop silo of short staves, almost complete.

of the opening. Care should be taken to see that the finished door opening is of uniform width from top to bottom. On the inside of the doorjambs and 1 inch back from the edges of the door opening, fasten 1- by 3-inch strips the back edges of which are beveled toward the wall.

Figure 40 shows a wooden-hoop silo made with short staves with braces between the hoops.

TIMBER-CRIB SILOS

ROUGH-CUT LUMBER PREFERRED

The timber-crib silo (fig. 41), built of 2- by 4- or 2- by 6-inch lumber and lined with boards or plaster may be economical in timber regions or where farm-cut lumber is available. It requires little skilled workmanship. It should not be built of green lumber as shrinkage will crack or loosen the lining. Rough-cut lumber is best when the lining is to be cement plaster, since the uneven edges and cracks hold it to the walls. If smooth lumber should be used, metal lath or wire cloth would be needed to support the plaster, but finished lumber is uneconomical in this type of silo. Timber-crib silos should have six or eight sides, each side not more than 6 or 7 feet wide. A six-sided silo 6 or 7 feet to the side has a cross-sectional area about equal to that of a cylindrical silo 10 or 12 feet in diameter.

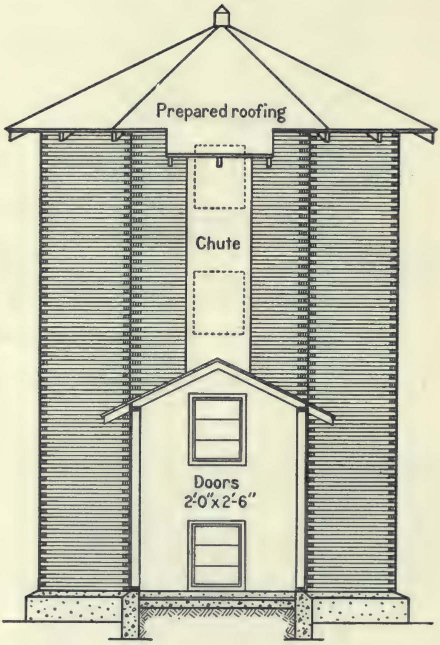

FIGURE 41.—Architect's drawing of a timber-crib silo.

CONSTRUCTION

It is best to make a pattern for the cribbing pieces first, since the foundation wall will be the same shape as the superstructure. The ends are cut to an angle of 60° to the long side of the piece for a six-sided and 45° for an eight-sided silo. The pattern can be laid out with a carpenter's square, as shown in figure 42.

After the pattern is made, it can be laid on the leveled site of the silo and the foundation marked off and built as described on page 8 Anchor bolts can be set in the foundation wall to which the bottom two or three layers of cribbing can be bolted. The successive layers of cribbing are spiked to the preceding layer with twentypenny nails, alternately lapping the end joints (fig. 43). Careful spacing of nails around the door opening will save much trouble when the doorway is to be cut out.

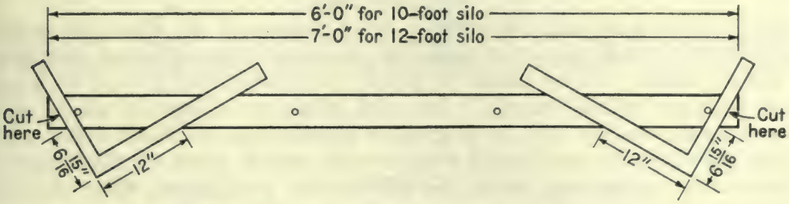

FIGURE 42.—Laying out a pattern for cribbing.

The door openings, in the middle of one side, can be cut out as the wall is built up, each cut-out being made when the wall reaches the level of the top of each door. The doorframes of 2- by 6-inch plank, are placed to extend inside the silo the thickness of the inside lining and are securely spiked. The 1- by 2-inch door-stop strips are nailed to the frame 2 inches from the inside edge.

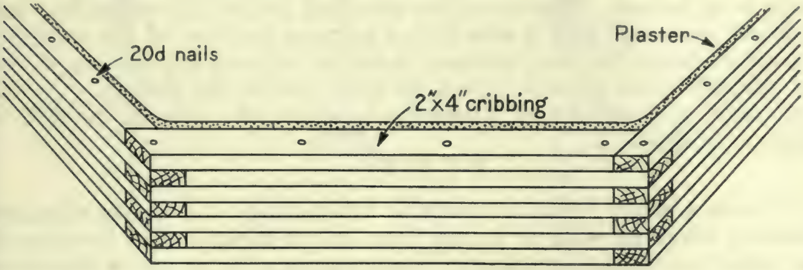

FIGURE 43.—Laying up cribbing.

FINISHING THE INSIDE

The inside surface of the wall can be finished with tongue-and-groove sheathing, flooring, or cement plaster. The corners are covered as much as practicable. Cement plaster is the most suitable and lasting. The plastering should be done in two coats, the first about one-half inch thick, the next one-quarter to three-eighths inch thick. For the first coat use 1 part cement to 2 parts clean sharp sand and one-eighth bushel of plaster hair to each barrel of cement. Hydrated lime or lime putty made by slaking lump lime is generally added to make the plaster work easier. The lime added to each batch should not be more than one-tenth the amount of cement used. The second coat should be applied before the first coat has dried and should be mixed 1 part of cement to 2 parts sand. The wall is finished with a concrete wash, as is a monolithic concrete silo.

The outside can be finished with siding, vertical boards and bats, or plaster, or it can be left plain. Unless the silo is to be built higher at a later date, it is best to cover the outside at once.

METAL SILOS

Metal silos are easy to erect. It is necessary to keep the inside painted with a refined tar or asphaltic preparation to prevent corrosion by silage acids. They must be firmly anchored and guyed to avoid wind damage while empty. In cold climates silage in metal silos freezes more readily and to a greater depth than in most other silos. These silos can be purchased complete in many parts of the country. The manufacturer may erect the silo, or the purchaser, with the help of two or three handy men, can do the work himself.

BELOW-GROUND SILOS

Silos with all or most of their storage capacity below the ground level have been successfully used in the semiarid regions of this country for many years. They fall into two groups, the pit silo and the trench silo. The pit silo is circular in form, dug as deep as desired or as the ground-water level will permit. It may have a curbing extending several feet above the ground. This type is popular in the Southwest and in other regions where the soil is firm and dry and the ground-water level is low. The trench or modified trench silo came into use 25 or 30 years ago and is now found in most sections of the country. If good drainage can be provided, it can be built in any section where the ground-water level is 3 feet or more below the surface. It has been used successfully in Mississippi, where the annual rainfall is about 60 inches.

PIT SILOS

Pit silos are not liable to storm or fire damage and in dry climates preserve silage as well or better than above-ground silos because of the uniform soil temperatures. The capacity of a pit silo is the same as that of a round above-ground silo of the same dimensions, and the required size should be governed by the factors previously discussed. Especial care must be used in entering pit silos since suffocating gases often accumulate in them.

LOCATION

In many soils it is impracticable and even dangerous to dig a deep pit, hence the farmer should know the character of the soil before attempting to construct a pit silo. The soil must be well drained, so that water will not stand in the bottom, and of such a nature that it will not readily cave. Soils containing large rocks are not satisfactory for pit silos, as the walls are likely to be defaced and weakened when the rocks are removed. Any firm, well-drained, and comparatively dry soil, free from seeps, rocks, and sand strata should be satisfactory. Where pit silos have not been tried, the farmer should observe the water table in a nearby well. If this is not possible, it is advisable to bore some 2-inch holes with a soil auger or pipe to the depth of the proposed silo and learn the character of the soil. The maximum height of ground water in the test holes will indicate the lowest point to which a pit silo should be dug.

If possible, the silo should be near the feed lot or barn, but the edge of the pit should be at least 6 feet away from the barn wall. In no case should the silo be so located that it will receive seepage or drainage water from barns, feed lots, or manure pits since contamination from these sources might result in the spread of disease.

CONSTRUCTION

A curb or collar 4 to 6 inches thick around the top of a pit can be laid out and constructed the same as an above-ground silo foundation wall (figs. 1 and 3), omitting the footing and anchors. A wall about 4 feet high is built on the concrete curb. This may be of concrete, lumber, concrete blocks, hollow tile, or brick. Woven-wire fencing has been used for this purpose; if this enclosure is well made it will keep persons or livestock from falling in, and the space enclosed can be filled with silage. Forms are necessary for building a concrete wall, which should be about 4 inches thick and reinforced with heavy woven-wire fencing or other reinforcing.

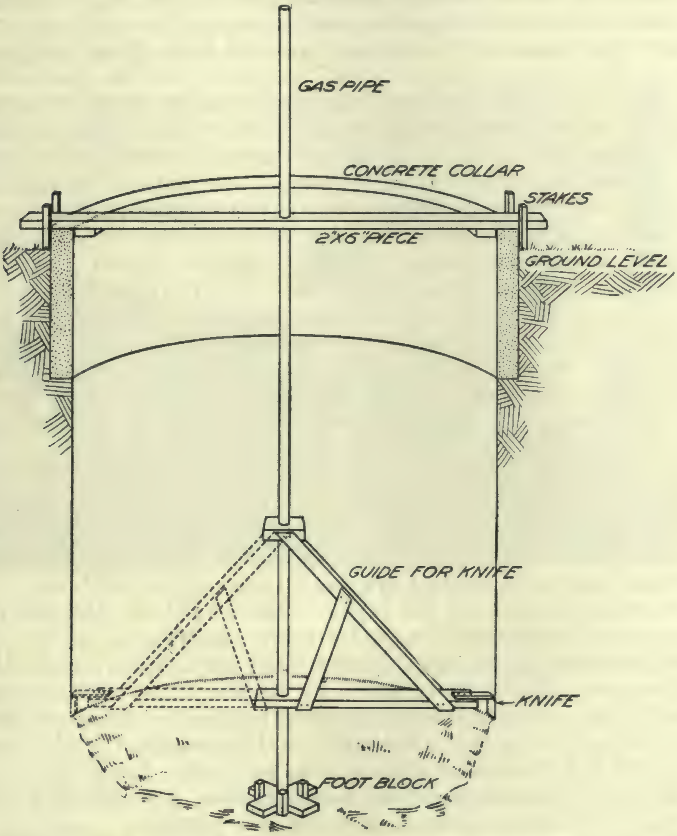

FIGURE 44.—Vertical section of a pit silo, showing device for keeping the walls smooth and plumb.

If a carrier of the overhead-track type is to convey the silage away from the silo, it should be erected while the curb is becoming set and before the pit is dug. The carrier can then be used to remove the soil from the pit. The hoisting apparatus can be used to lift out the soil, but it will pay to use a horse or team to lift it.

After the concrete curb has set well—in about 3 days—the pit may be dug. Remove the soil, digging straight down from the inside of the curb. Be sure to keep the wall perpendicular and smooth. If the wall slopes inward, the silage will settle away, leaving an air space, and some silage will be spoiled.

Several devices have been used to aid in keeping the wall straight and smooth. A simple plumb line is most often used, and a straightedge made from a 1- by 4-inch piece, used in connection with an ordinary carpenter's level, assists in keeping the wall both plumb and smooth. Figure 44 illustrates a device which has been used in the Southwest. The stakes next to the curb and the blocks nailed on the lower surface of the 2- by 6-inch piece are put in place before the digging of the pit is started. The hole in the 2- by 6-inch piece, through which the pipe passes, is bored directly over the center of the silo. After each section of the pit is dug, the 2- by 6-inch piece is put in place, and a plumb line is dropped through the hole to locate the exact center in the bottom. Then the foot block is staked in place, and the pipe lowered through the 2- by 6-inch piece, through the guide, and into the hole in the foot block. The guide is then revolved, and the knife shaves the wall smooth or indicates irregularities in the wall. When the wall has been smoothed to the approximate level of the foot block, the apparatus is removed, this section of the wall plastered, and digging is then begun for the next section. This is repeated for each 5- or 6-foot section excavated.

In soils not too sticky when wet, digging will be made easier if enough water is run in at night to soak the ground. When rocks are encountered they should be removed without blasting, if possible. In case blasting is done, no one should enter the pit after the blast until the air and poisonous gases have been replaced by fresh air. A limb of a tree, or a blanket, or the bucket used to lift out the soil may be used on a rope to agitate the air for a few minutes.

When the removal of rocks destroys the smooth surface of the wall the defacements should be repaired by the use of metal lath or similar material. The metal lath or mesh should cover the damaged area and extend well out over the solid wall, and be secured with long, iron pins, so that it is flush with the surrounding wall. Large holes may be partly filled with concrete before being covered with the lath. Adobe mud, where available, is often used for this purpose.

LINING THE PIT

When 5 or 6 feet have been excavated, the wall should be plastered about 1 inch thick with a mortar of 1 part cement and 2 or 2½ parts of clean, sharp sand. Two coats will be required to do this, and at least 2 hours should elapse between the applications. However, the second coat should be applied before the first has become completely dry. A lining 1 inch thick is sufficient in some soils, but in soils not very firm a 1½- to 2-inch coating on the wall is safer. In any case it should be reinforced with woven wire or metal lath. It will be found desirable to start the lining an inch or so below the curb and leave this band bare until the silo is completely dug. This will allow the curb to settle without buckling or cracking the lining below.

Before a plaster lining is applied the wall should be dampened to prevent the dry soil from absorbing moisture from the mortar too rapidly. Before the plaster is set, apply with a whitewash brush one or two coats of a wash of pure cement and water, mixed to a creamy consistency. The application of this last coat assists in making the wall stronger, smoother, airtight, and almost waterproof. Keep the wall damp for several days, as this will help the plaster to harden properly and make the wall stronger.

After the first section of 5 or 6 feet has been lined with the mortar and cement wash, digging may be resumed, and so on until the desired depth is reached. In this way the danger of caving and the necessity of building scaffolding for the application of the lining are eliminated.

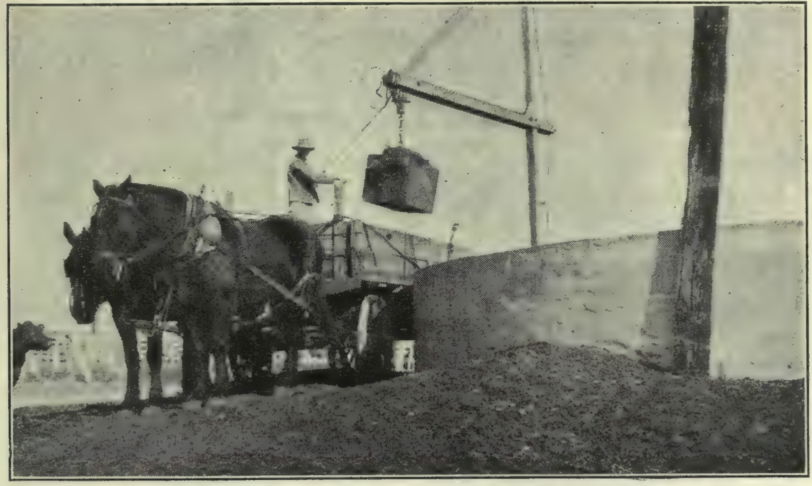

FIGURE 45.—Removing silage from a pit silo.

Linings of concrete, brick, tile, or stone can be used as described on page 56 under trench silos. Such linings may vary from 4 to 8 inches in thickness.

An inexpensive covering of some sort should be placed over the silo. A simple board roof is sufficient. A space of about 2 feet or more should be left at the top of the wall to allow for free circulation of air, which makes less probable the accumulation of gases. However, there is always need for caution where these gases can accumulate. See warning on inside of front cover.

Where a man furnishes all his own labor, obtains sand and gravel at a small cost, and installs a home-made hoisting apparatus, a pit silo of considerable capacity can be constructed at small cost, as the only cash items would be cement and wire mesh or metal lath.

HOISTING DEVICES AND FEEDING EQUIPMENT

The problem of hoisting and feeding silage from pit silos is not difficult. Practically all the devices now in use are inexpensive home-made affairs. One of the most successful and simple types is illustrated in figure 45. It consists of a swinging crane, pulleys, rope, and

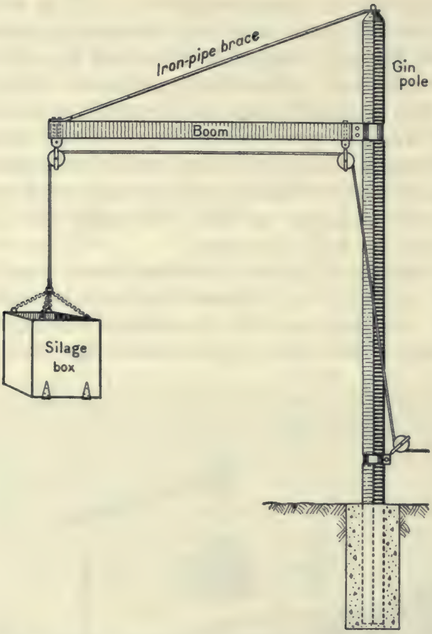
Iron-pipe brace
Gin pole
Boom
Silage box

FIGURE 46.—Hoisting device for removing feed from a pit silo; the mast should be a 6- by 6-inch timber for 500 pounds of silage and the boom 4 by 4 inches. If it is desired to remove 1,000 pounds at a time the mast should be an 8- by 8-inch timber.

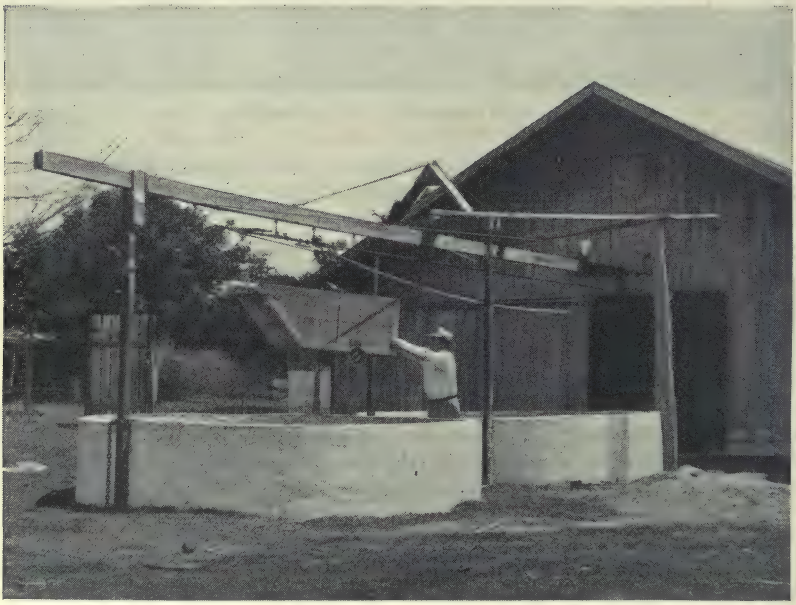

FIGURE 47.—Twin silos with a hay carrier and hoist for removing silage.

a box for the silage. A 4- by 6-inch piece may be used for the upright or mast, and a 4- by 4-inch piece for the boom. Only sound timbers should be used. The upright should be braced from the top with heavy guy wires securely anchored. Figure 46 illustrates a mast and the different members of a hoisting device that does not require guy wires. A horse may be used to lift the silage. The silage box after being filled and hoisted can be swung over a wagon or attached to a trolley on an overhead track, or placed upon a truck or wagon and hauled to feed bunks or mangers. Such a hoisting device may be so placed that it can be used to empty two or even three silos. The silage box should have a trip bottom, end, or side so that it may be unloaded easily.

Figure 47 shows how a regular hay carrier and outfit is used to lift and feed silage from a pit silo. The track can extend into the barn or in front of the feed bunks.

A farmer should install a hoist and feeding equipment that conform to his particular needs, keeping in mind the desirability of convenience, durability, and safety.

TRENCH SILOS

The trench silo has many advantages. Unlined, it can be made for labor cost only, so that often a tenant farmer can afford to make one. With the use of a team or tractor, it can be made quickly in emergencies. The repairs are limited to smoothing the walls and cleaning drains. It is adaptable to small herds and can be filled with a small cutter, with or without a blower. This type affords easy access to the silage. It can be built as a temporary silo and lined for permanent use later.

A disadvantage is that there is considerable spoilage, ranging from 5 to 25 percent. Also, unless lined, the side walls tend to cave, and when rain occurs during the feeding season, the bottom of the trench may become muddy and make entrance to the trench so difficult as to require a temporary road of planks. Special care is necessary in packing the silage, and suitable drainage must be supplied if the site does not have adequate natural drainage. The open trench is dangerous unless fenced or roofed, and it is not easily filled in when abandoned. Special care must be taken to guard against suffocating gases in the bottom of a trench silo, especially when it is in level ground. See the warning on the inside of the front cover.

SIZE, CAPACITY, AND COST

The cross-sectional area of a trench silo should be proportioned to the size of the herd and weight of silage to be fed daily. (See table 1.) The length can be adjusted to suit the amount of silage required for a given feeding period, allowance being made for from 5- to 25-percent spoilage. Where the silo is unlined and is to be used each year, the cross section should be made small enough to allow for trimming and evening the sides before filling without increasing the capacity beyond the daily feeding requirements.

Normal corn silage in a trench, well-packed by tractor or animals, should average from 30 to 40 pounds per cubic foot. In table 11, which gives dimensions, areas, and capacities, the density assumed is 35 pounds per cubic foot. When the silage is to be fed during cold weather only or in very cold climates, the cross-sectional area can be increased and only 2 or 3 inches fed per day.

TABLE 11.—*Dimensions, cross-sectional area of trench silo and weight of silage in 4-inch layer and per lineal foot*

Side slope per foot of depth (inches)	Depth	Bottom width	Top width		Cross-sectional area	Weight of 4 inches of silage	Weight per lineal foot
	Feet	*Feet*	*Feet*	*Inches*	*Square feet*	*Pounds*	*Pounds*
3	4	5	7	0	24	280	840
4	4	6	8	8	29	338	1,015
5	4	7	10	4	33	385	1,155
3	6	6	9	0	45	525	1,575
4	6	7	11	0	54	630	1,890
5	6	8	13	0	63	735	2,205
3	8	6	10	0	64	747	2,240
4	8	7	12	4	77	898	2,695
5	8	8	14	8	91	1,062	3,185
3	10	6	11	0	85	992	2,975
4	10	8	14	8	113	1,318	3,955
5	10	10	18	4	142	1,657	4,970

The only cost of constructing unlined trench silos is the labor. The time required to dig out a trench will depend on the size, type of soil, and the equipment used. Two men with a team and slip scraper should move about 20 cubic yards in an 8-hour day in heavy clay soils and 30 cubic yards in light clay or loam. If a trench 7 feet wide at the bottom, 11 feet wide at the top, and 6 feet deep is to be dug, and 45 tons of silage is to be stored, a trench 50 feet long will be needed, allowing for 5-percent spoilage, and the approximate time can be estimated as follows: Table 10 gives the cross-sectional area as 54 square feet. Multiplying this by the length (50 feet) and dividing by the number of cubic feet in a cubic yard (27) gives 100 cubic yards as the quantity of earth to be moved. If the soil is a heavy clay about 5 days of 8 hours would be required, and if a light soil about 3 days. Lining the walls makes the cost much higher. In the silo mentioned, the slant height of the wall is 6 feet 4 inches. If allowance is made for an 8-inch footing and a 6-inch curb, the total wall needed would be 7 feet 6 inches high. Multiplying the 7 feet 6 inches by 50 (the length) and by 2 (two sides) gives 750 square feet of wall. Seven hundred and fifty square feet of 4-inch concrete wall would require 750 times one-third, or 250 cubic feet (9.26 cubic yards) of concrete. Two hundred feet of 45- or 48-inch hog wire would be needed for reinforcing. Concrete usually costs from $8 to $12 per cubic yard in place. For this type of wall a form 10 to 20 feet long can be built and moved along the trench as the sections are completed. Estimates of wall linings of other types can be based on the number of square feet of wall required.

LOCATION

A trench silo should be as convenient as possible to the feed lot or barn, yet where it will not interfere with farm operations, be unsightly or receive seepage or drainage from barns, feed lot, or manure pit. A hillside or slope is desirable because one end may open level with the ground surface, facilitating the removal of silage and allowing water entering the trench to drain out. Drains should be made around the trench to intercept surface water. Where only level ground is available, the trench should be dug with sloping ends to permit driving in and out during construction, filling, and feeding. Where the ground is impervious, a drain can be run from the lowest part of the trench to a dry well or to lower ground to take care of water trapped in the trench when partially or entirely empty. In some cases water is drained to the lower end of the trench and bailed out. Figure 48 illustrates lay-outs for trenches dug under different conditions of topography and drainage.

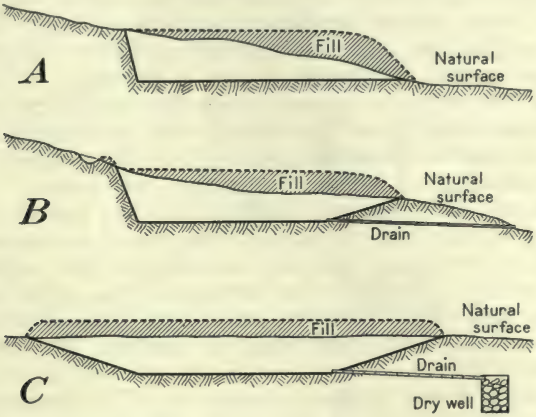
A
Fill
Natural surface
B
Fill
Natural surface
Drain
Natural surface
Fill
Drain
C
Dry well

FIGURE 48.—Lay-outs for trench silos under different topographical conditions: *A*, On a hillside; *B*, on a gentle slope; *C*, on level ground.

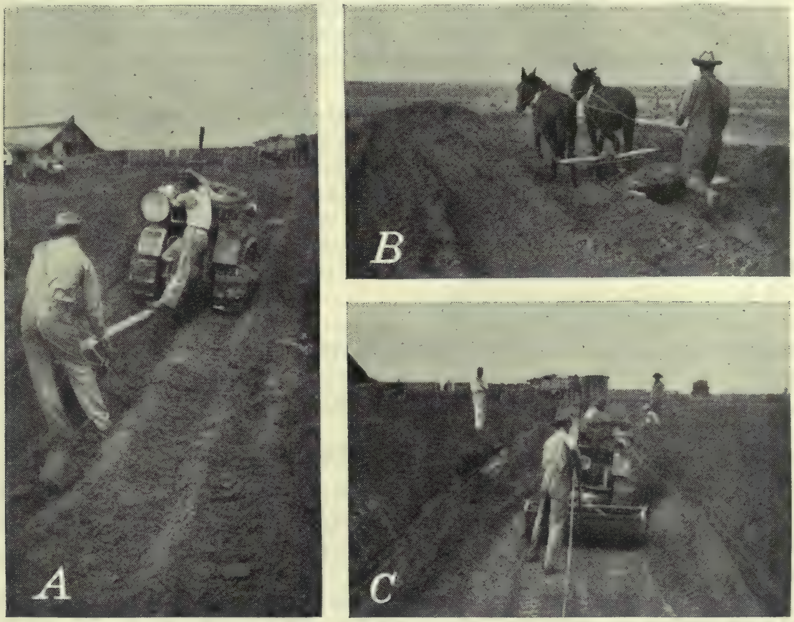

FIGURE 49.—Digging a trench silo: *A*, Plowing; *B* and *C*, removing the soil.

DIGGING THE TRENCH

After the trench is staked out, the ground is plowed (fig. 49), but not so near the stakes as to prevent the smoothing down of the side slope. The loose ground is then removed, generally with a slip or fresno scraper (fig. 49), and another layer plowed. These operations are continued until the desired depth is reached. If the earth removed from the trench is placed along the sides, the ground at the sides will slope away from the trench, and the depth of the trench below the natural level of the ground will be reduced. Doing this reduces the drainage of surface water into the trench.

The sides may be trued and kept to slope as the trench is dug, or this can be done after the bottom of the trench is reached. A spade and mattock or grubbing hoe may be used for this purpose.

Another method, especially for emergency use, is to dig the trench very shallow and when filling it, stack the silage several feet above ground, covering it with dirt from the trench. In some European countries metal forms about 2 feet high are used to hold the silage while the dirt is being banked around it. The forms are raised as the mound is built up, and the top is finally covered with earth. This has the advantage of requiring only a shallow trench, but more labor is required to cover the mound.

Regardless of whether the trench is to be lined or not, the sides should not slope more than is necessary for the type of soil. A slight slope keeps the silage tight against the sides as it settles but too great a slope will hinder settling. Trenches have been dug with walls ranging from vertical to almost 45° slopes. Slopes of from 3 to 5 inches per foot of depth, as noted in table 10, are recommended. If a slope of much more than 5 inches to the foot is required to make the side walls stable, they should be lined.

When the trench silo is not to be lined, the edges must be protected against caving. Posts can be set at regular intervals and planks or poles placed along the edge. A fence must be built to keep persons and animals from falling into the trench.

If the trench is to be lined later, the cross section should be a little smaller than the final silo desired, to allow for truing the walls after use. The allowance will depend on the stability of the soil.

It is probably more important to line a trench silo intended to be filled and emptied each year than one used to carry over feed from good years to lean, since most wall weathering occurs when the trench is empty. If the trench is to be used to keep feed for several years, it should be well drained to avoid excessive spoilage.

TYPES OF LINING FOR TRENCH SILOS

Walls of trench silos can be lined with cement plaster, concrete, rubble masonry, brick, tile, or wood (fig. 50). Wood linings are not very lasting unless creosoted and are not economical except where local lumber is plentiful.

Where soil conditions are good, cement plaster makes a good lining if 2 or 3 inches thick and reinforced with wire mesh. The wire mesh is fastened to the wall with spikes or iron pins. A plaster made of 1 part cement to 3 parts sand and 3 parts crushed stone or pea gravel is suitable and should be applied in horizontal strips from 12 to 15 inches high to prevent sloughing. Horizontal boards as wide as the lining is thick, placed on edge about 2 feet apart along the walls of the trench can be used to level the surface of the lining. One strip should have time to set before a second is applied. A finishing coat of plaster mixed 1 part cement and 3 parts sand is applied with a trowel. A cement wash may also be applied. Where a stronger wall is desired, a concrete lining 4 to 6 inches thick can be placed by using forms and reinforcing, as shown in figure 50, *B*.

In localities where native stone is plentiful, a rubble masonry wall can be made at low cost except for labor. The wall should be from 12 to 16 inches thick, it should be laid up with a cement mortar made of 1 part cement to 6 parts of sand, and the surface should be covered with from one-half to three-fourths inch of 1:3 mix of cement plaster (fig. 50, *A*). If dressed stones are used, the wall can be built 8 inches thick with a 1:3 cement mortar. Brick and tile can be used in the same manner (fig. 50, *E* and *F*). Where there is any danger of the earth walls sliding, reinforcing rods can be placed between courses from 18 inches to 2 feet apart, and the slope of the wall flattened to 5 inches per foot of depth.

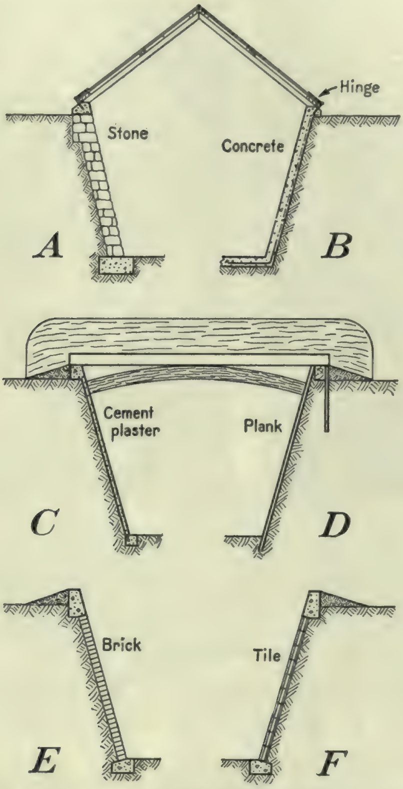

FIGURE 50.—Different types of lining and roofs for trench silos: *A*, Stone; *B*, concrete; *C*, cement plaster; *D*, plank; *E*, brick; *F*, tile.

Where the ground-water level is close to the surface and the trench silo is extended above ground by banking (fig. 48), care must be taken to make the wall lining strong enough to prevent cracking.

A trench silo may be filled with either cut or uncut forage (fig. 51, *A* and *B*). If the silage is uncut, the cost of filling is less, but removal requires more labor. However, with a knife similar to that shown in figure 51, *A*, the stalks may be cut and easily removed. When a trench silo is filled it should be packed by a team (fig. 51, *B*) or a tractor

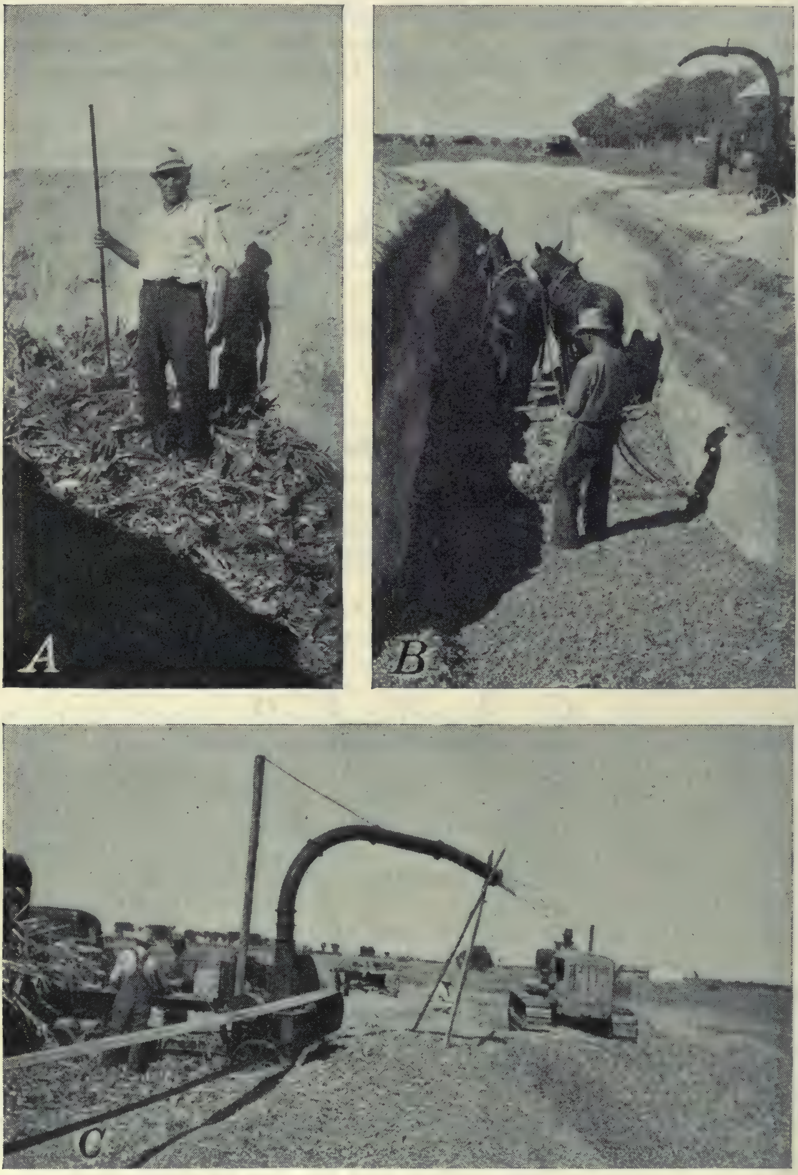

FIGURE 51.—Filling and packing a trench silo: *A*, Knife for chopping out uncut silage; *B*, using team to spread and pack silage; *C*, packing with tractor. Note that the silage is above grade.

(fig. 51, *C*) and heaped from 2 to 4 feet higher than the trench to allow for settling. In the South, the top is usually covered with straw, weeds, or rakings, wet down, and a layer of earth from 4 to 6 inches deep (fig. 52) added. In the North, because of snow and freezing weather, a roof is desirable. Using straw, hay, or stalks will give protection against freezing (fig. 50), but roofs of wood frames covered with boards or sheet metal are more serviceable. They may be made in sections which can easily be removed or hinged to swing back along the top of the trench.

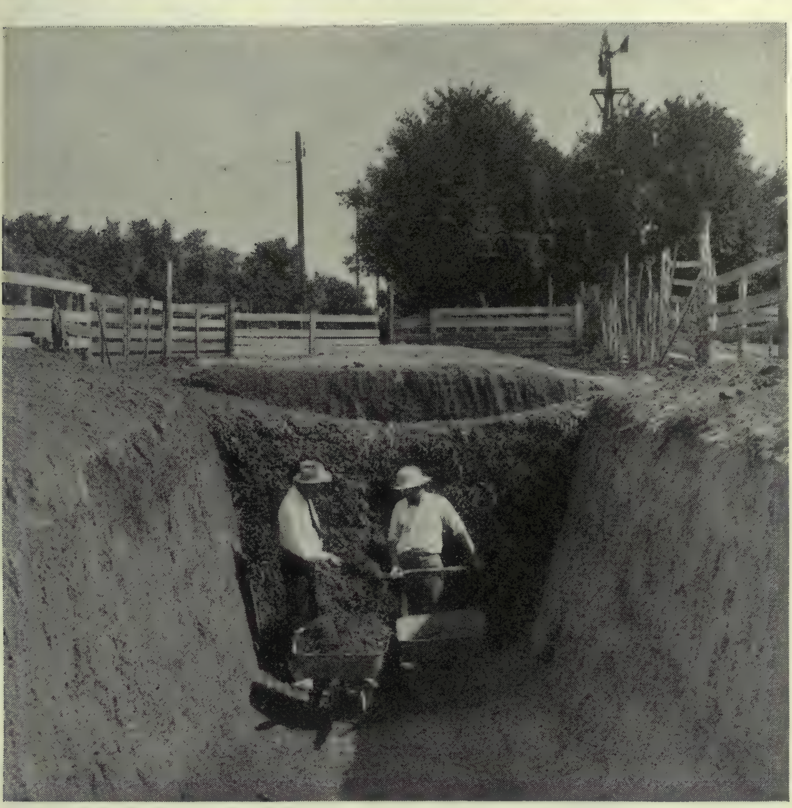

FIGURE 52.—Opened trench silo, showing how soil was used as a covering.

If the silo is not to be opened for a long period, it should be inspected regularly and any cracks that have formed in the covering filled with dirt. Silage has been kept in good condition for 12 years in unlined trench silos.

TEMPORARY SILOS

Silos of woven wire, picket fencing, or snow fencing are used throughout the country to meet emergencies and to supplement permanent silos. They are low in cost, can be erected on short notice when drought or bumper crops make them needful, and require no doors. There are few records of the capacities of temporary fence silos. Those reported indicate that the height is generally about the same as the diameter and that the capacities are within the ranges given in table 12.

TABLE 12.—*Materials required for different sizes of lined fence silos and approximate cost*

Size of silo		Capacity	Fencing [1]			Length of No. 9 wire [2]	Paper [3]	Cost of material
Diameter (Feet)	Height		Pieces	Length of each				
	Feet	*Tons*	*Number*	*Feet*	*Inches*	*Feet*	*Feet*	*Dollars*
12	12	15 to 18	3	38	3	250	138	21
14	16	28 to 34	4	44	6	375	208	30
16	16	38 to 44	4	50	10	435	236	35
18	20	76 to 88	5	57	1	600	325	47
20	20	90 to 105	5	63	6	665	350	52

[1] If slat or snow fencing is used these lengths should be measured after the wire has been stretched.
[2] 2 hoops for each width of fencing.
[3] 4 feet wide.

FENCE SILOS

Fence silos may be built with or without a lining. Snow fence, made of wire and slats, probably has been used most widely and has given the best results. The slats keep the fence from buckling as settling occurs and the upper and lower rings slide onto each other readily.

All kinds of building and roofing papers, with and without fibrous reinforcement may be used as lining. Reinforced papers give better results. Some papers are treated to resist acid and certain bacterial action. According to tests conducted by the Bureau of Dairy Industry, lining reduces spoilage more than half. In a South Dakota survey of 40 silos, 18 of which were unlined, the loss around the walls of the unlined ones varied from 5 to 18 inches of silage and averaged 10.5 inches. In lined silos it ranged from 2 to 18 inches of silage and averaged 8.3 inches. The loss in individual silos ranged from 4.41 percent to 42.7 percent.

Table 12 lists the materials required for lined fence silos. In addition to the items shown in the table, some spring clothespins will be needed to hold the lining to the sides while filling the silo. Some ¼- or 5/16-inch turnbuckles to tighten the wire are desirable.

The circumference of the silo is laid out on ground as nearly level as obtainable in a good location, as described under laying out foundations (p. 8). The site should then be leveled. Set up the fencing in a true circle and securely fasten the ends together. Place the lining on the inside of the fence so the edge folds in along the bottom and clamp it temporarily to the top of the fencing strip with clothespins or other clamps. This section can now be filled within 6 inches of the top. The second section is then placed and held in position temporarily by binding the slats together about every 18 inches with twine. The bottom lining is placed inside the second course of fencing, and the lining for the second tier is placed so as to lap over the inside of the bottom strip. This prevents the fence from tearing the lining as the silage settles. The second section is filled to half its height. Then two No. 9 reinforcing wires are put around the first tier, pulled taut, and twisted together or fastened with small turnbuckles. Turnbuckles are inexpensive and make it easier to handle and salvage the wire. The twine used to hold the second tier of fencing in place may now be removed to allow it to settle freely inside the first tier. Other tiers are handled in the same manner till the silo reaches the desired height, usually not less than three nor more than six tiers.

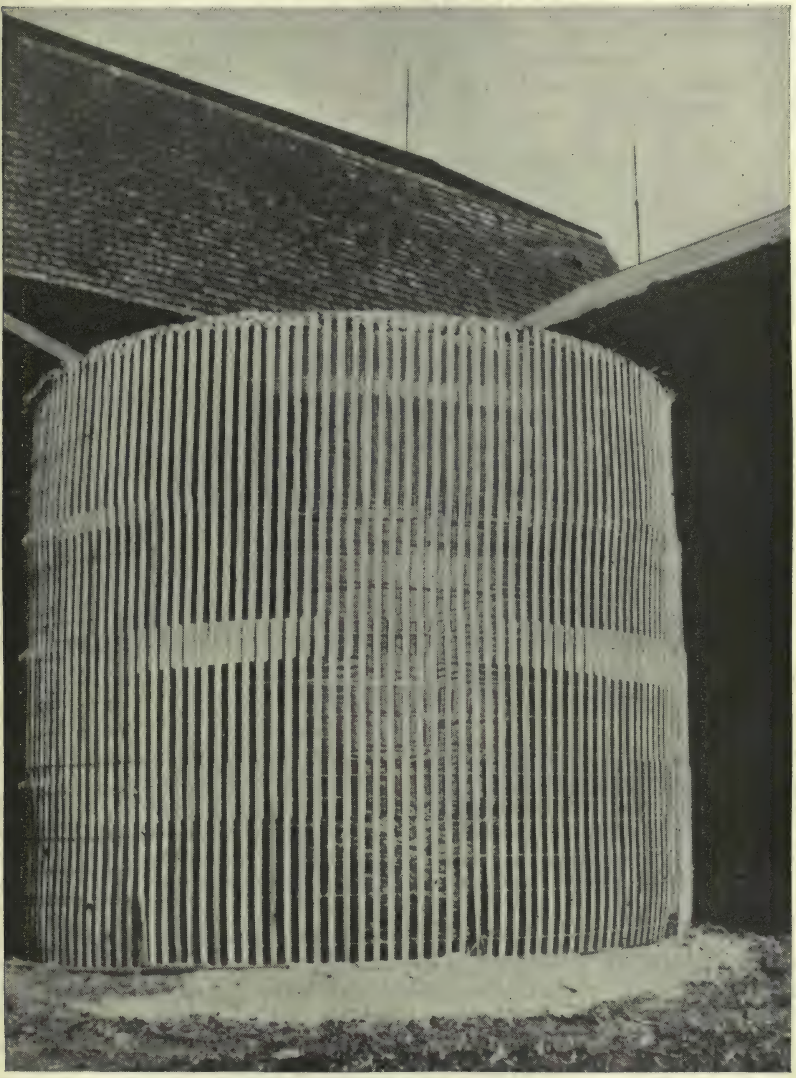

FIGURE 53.—Temporary fence silo.

Generally the height of an unsupported fence silo should not exceed its diameter. If it is built more than one tier higher than this, it should be surrounded by from 5 to 10 poles 6 to 8 inches in diameter firmly set in the ground. The poles are set against the silo walls and may be tied to each other above the silo with No. 9 wire and anchored for wind bracing, but in no case should the walls of the silo be fastened to them. Figure 53 shows a well-constructed snow-fence silo lined with reinforced paper. Note that the earth removed to level the building site is outside the silo, where it will not affect the even settlement of the walls.

STACK SILOS

If roughage is plentiful, stack silos can be used in emergencies if the prospect of a high percentage of loss does not preclude their use. Either cut or uncut roughage can be stored in them. If not cut, the roughage is simply stacked in the most desirable form. Since losses occur principally around the outside of the stack, the larger the stack the smaller the percentage of loss. The stack should be packed as tight as possible to exclude air. It is best to feed out this type of silage by slicing layers off one end of the stack with a hay knife. When a cutter is available the cut material can be placed in a shell formed by bales of hay or straw, corn bundles (fig. 54), or loose weeds or grass. This method results in less spoilage and the silage is much easier to feed.

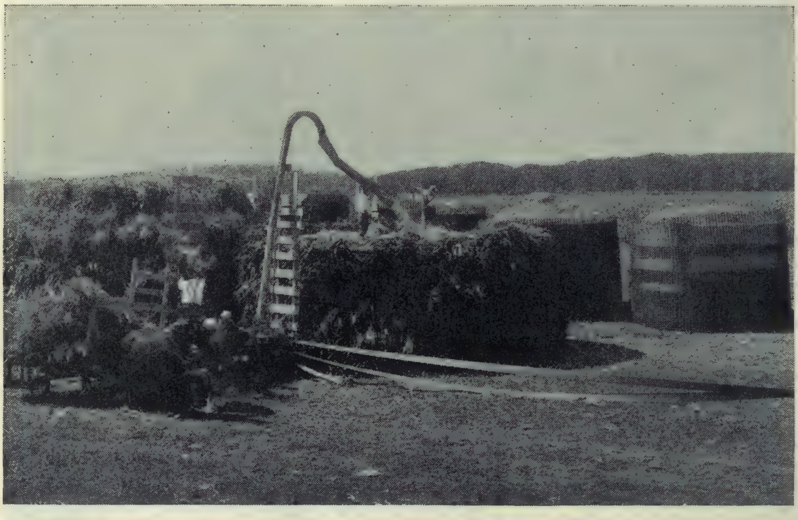

FIGURE 54.—Filling a corn-bundle silo with cut silage. Note the fence silos in the background.

When bales of hay or straw are used for a silo they should be tied together with No. 9 wire as in the case of a fence silo. When a man knows before the material is baled that he is going to use the bales in building a bale silo, he can curve the bales by tying one of the baling wires shorter than the other. Tying one wire 6 or 7 inches shorter will give curve suitable for about a 16-foot silo.

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CONTAINERS *for* *Fruits and Vegetables*

FARMERS' BULLETIN
NO. 1821

U.S. DEPARTMENT
OF AGRICULTURE

PERHAPS the most natural question concerning containers for fruits and vegetables and one often arising in one form or another is, What container is standard for a particular product, or in a particular section? For few products or sections is there a definite, final answer to that question.

Federal standards are in force for barrels and for the several types of baskets and hampers, but most fruits and vegetables are packed in containers for which no such standards have been established—in crates, boxes, cartons, drums, and sacks.

These containers are used in such a wide variety of deceptive sizes and shapes that they impose an unnecessary burden on the distributing trade—and hence on the consumers and growers.

It is generally believed that the principle of standardization could be applied to these containers to the immediate benefit of all parties concerned.

Without attempting to recommend one type of container over another, this bulletin sets forth under each commodity the containers most commonly used in the important shipping sections.

This bulletin supersedes Farmers' Bulletin No. 1434, Standard Baskets for Fruits and Vegetables, and Farmers' Bulletin No. 1579, Containers Used in Shipping Fruits and Vegetables.

Washington, D. C. **Issued April 1939**

CONTAINERS FOR FRUITS AND VEGETABLES

By L. C. Carey, *marketing specialist, Bureau of Agricultural Economics*

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INTRODUCTION

MORE than a million carloads of fruits and vegetables are shipped annually in this country. They are shipped by railroad, by steamboat, and by motortruck. As the greater part of this produce, probably 85 to 90 percent, is packed in some kind of container, more than a billion packages are required, representing an investment of several million dollars. Thus the containers used in shipping fruits and vegetables are of vital importance in the satisfactory marketing and distribution of these commodities.

TYPES OR CLASSES OF CONTAINERS

The containers used for fruits and vegetables may be divided into four principal classes—baskets, crates and boxes, barrels, and sacks. Containers of a fifth class, cylindrical drums, have a limited use.

There are five types of baskets—till baskets, hampers, round stave baskets, splint or market baskets, and Climax or grape baskets.

Crates and boxes are grouped together because in the trade consistent distinction between them has not been preserved. Whether constructed of rotary-cut or sawn material, the ends, sides, tops, and bottoms may be solid, paneled, or slatted, in various combinations of single pieces and cleated units. Typical boxes are usually assembled with nails, but many crates are now bound together by means of encircling wires stapled to the units and closed with interlocking wire loops. Cartons, which come in this group of rectilinear containers, are made of either corrugated or solid fiberboard.

Barrel construction is usually classified as stave or veneer; some have wooden heads in both ends and others are closed at the top with cloth or burlap.

The cylindrical drum, at one time extensively used for certain varieties of grapes, has come into use for certain other products, such as brussels sprouts, and in a slatted form for citrus fruits, potatoes, and similar products.

Sacks are generally made of jute, but many are now made of cotton sheeting and of paper. For certain products, like onions, open-mesh bags are now used almost exclusively, and this style is being used increasingly for such products as citrus fruits, cabbage, green corn, and peas.

CONTAINERS STANDARDIZED BY LAW

STANDARD BARREL ACT, 1915

A question that arises often in one form or another concerning containers for fruits and vegetables is, What container is standard for a particular product or in a particular section? Strangely enough, of the four great classes of containers, standards have been established by Federal law for only two—baskets and barrels.

The first to be so established was the standard apple barrel in 1912. In addition to fixing the size and dimensions of the apple barrel, the Standard Apple Barrel Act set up certain standardized grades for apples. The grades for apples have been superseded by further developed grades so that with the passage of the Standard Barrel Act in 1915 the Apple Barrel Act, while still on the statute books, has become obsolete.

The Standard Barrel Act established two standard barrels (1) the standard fruit and vegetable barrel having the same dimensions and capacity as the standard apple barrel and (2) the standard cranberry barrel, of entirely different capacity and dimensions. It also provided three standard subdivisions of both, the three-fourths, one-half, and one-third barrel. None of these barrels and no subdivision bears a basic relationship to the standard bushel. The cranberry barrel was designed to hold 100 pounds of cranberries and has a capacity of 5,826 cubic inches or slightly less than 87 quarts. The fruit and vegetable barrel (fig. 1) both in capacity and dimensions is substantially the same as the commonly used flour barrel of that day. It has a capacity of 7,056 cubic inches and although generally considered to be the equivalent of 3 bushels, it actually contains 604.7 cubic inches, or 9 quarts, more than 3 bushels, and is sometimes referred to as a 13-peck barrel. Except in the case of the one-third cranberry barrel, which is no longer used, no appreciable use has ever been made of the small-sized barrels.

The act does not apply to barrels used for products packed and sold exclusively by weight or numerical count, an example of which is the 4-bushel barrel sometimes used for bunched vegetables in the South.

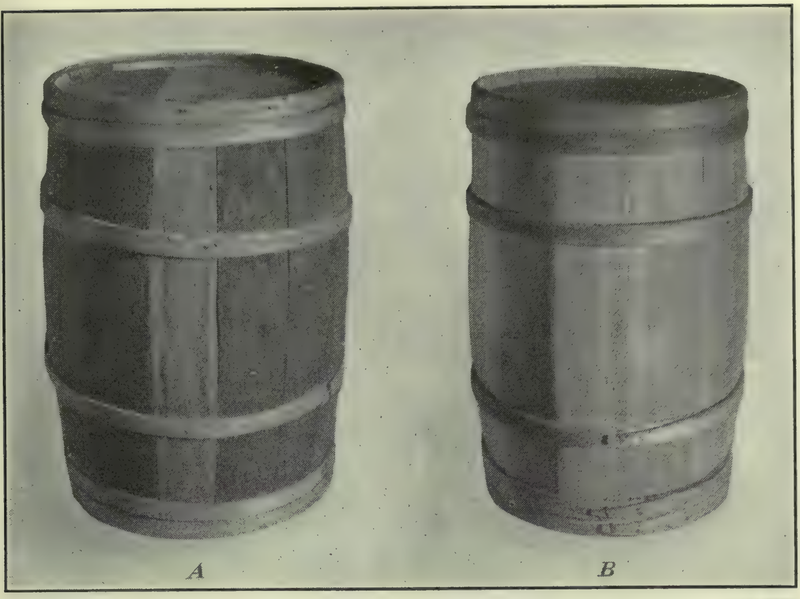


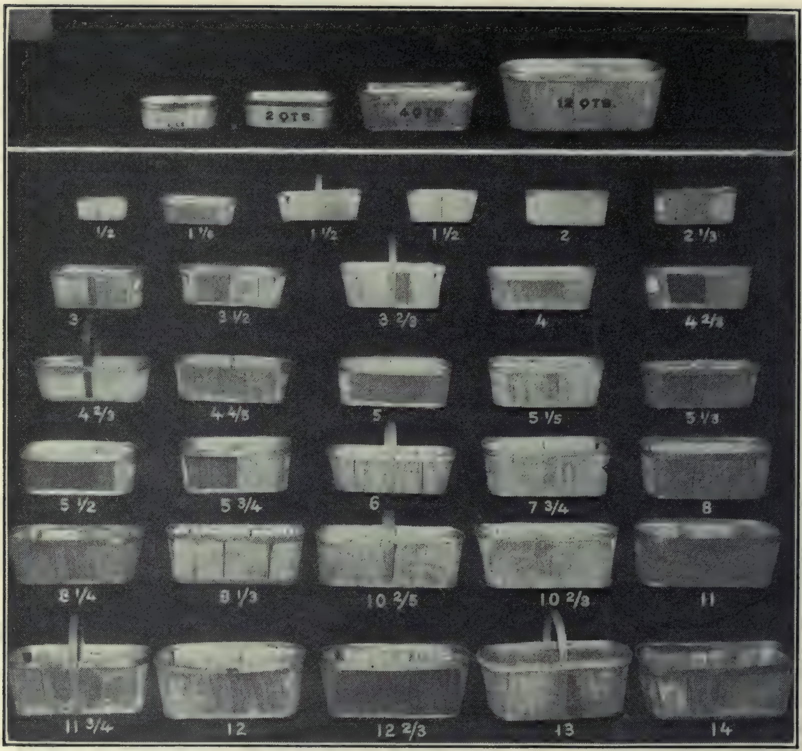
FIGURE 1.—*A*, United States standard fruit and vegetable barrel; *B*, the cranberry barrel.

STANDARD CONTAINER ACT, 1916

Two Federal laws govern the manufacture, sale, and shipment of hampers and baskets for fruits and vegetables. The Standard Container Act of 1916, enacted under the commerce clause of the Constitution, established three standard sizes—2-, 4-, and 12-quart—and prescribed the dimensions of Climax baskets for grapes and other fruits and vegetables. As amended in 1934, the act also now provides for and prescribes the dimensions of a 1-pound Climax basket for mushrooms and restricts its use to that product (fig. 2).

This act also fixed the standard sizes of berry baskets and other containers for small fruits, berries, and vegetables, requiring them to be of ½-pint, 1-pint, or 1-quart capacity, dry measure, or a multiple of the dry 1 quart. Until superseded by later legislation, this section of the act applied to baskets of all types, including hampers, but at present its application is restricted chiefly to such containers as small till baskets that are of the same general form and construction as berry baskets (figs. 3 and 4).

No dimensions are prescribed. Consequently, berry baskets and till baskets of various shapes and construction are in more or less common use in different parts of the country (fig. 5). Till baskets are either square or oblong and, when made of wood, are bound at the top with either wooden or metal bands. The manufacture and use of the square type, many of them made of paper, is confined mainly to the Pacific coast.



BAE 5276 AND 2722

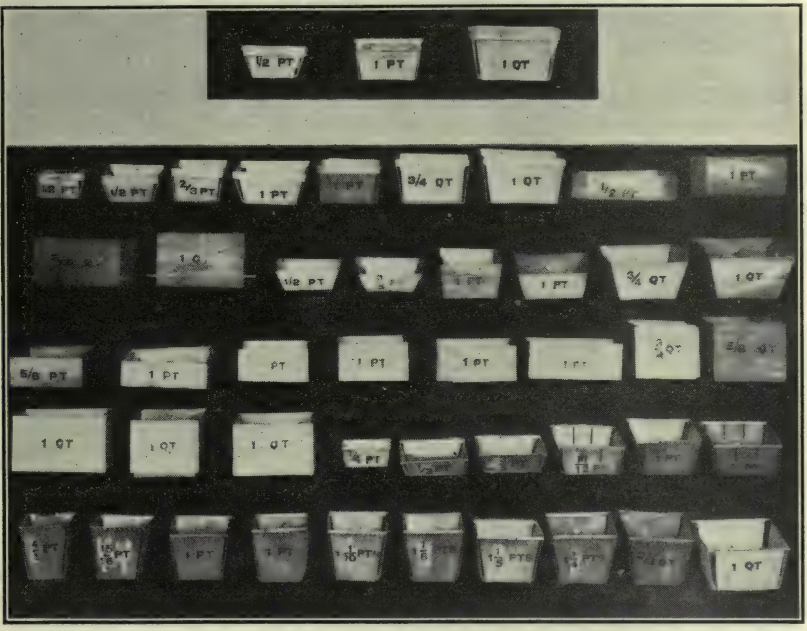
FIGURE 2.—Upper, United States standard 1-pound mushroom basket, and 2-, 4-, and 12-quart Climax or grape baskets; lower, some of the numerous sizes and varying shapes of Climax baskets in general use before 1917.

STANDARD CONTAINER ACT, 1928

The Standard Container Act of 1928 fixed the standard sizes of hampers, round stave baskets, and splint or market baskets. This law differs from the Standard Container Act of 1916 in several notable respects. Like the Standard Barrel Act, it was enacted under the weights and measures clause of the Constitution and hence applies in intrastate as well as interstate transactions. It prohibits the manufacture, sale, or shipment, of hampers, round stave baskets, and splint baskets, filled or unfilled, the dimension specifications for which have not been submitted to and approved by the Secretary of Agriculture, and it restricts such approval to containers that are of proper standard size and not deceptive in appearance. Under these provisions a marked degree of uniformity in the size, form, and shape of these containers has been brought about.

Nine standard sizes of hampers and round stave baskets are provided: ⅛, ¼, ½, ⅝, ¾, 1, 1¼, 1½, and 2 bushels. Not all of these are commercially important. For instance, the 2-bushel hamper has never been used for fruits and vegetables. However, in retail stores, farmers' markets, and roadside stands the three smaller sizes are common in the New England and Middle Atlantic States. The ⅝-bushel hamper is preeminently a cannery package particularly for tomatoes, but serves also as a general marketing container in Philadelphia and surrounding territory. The use of the 1¼-bushel hamper has been confined to the shipment of green peas and beans from North Carolina, and the use of the ¾-bushel hamper to similar products originating in the Southeast and Gulf States. The two most important hampers for shipping purposes are the 1- and 1½-bushel sizes (fig. 6).

Of the nine standard sizes of round stave baskets only four are commercially important—the ⅛- and ¼-bushel sizes, used chiefly in roadside markets, and the ½- and 1-bushel sizes, used for shipping (fig. 7). The origin of the term "round stave" is obscure, but it seems fairly certain that it was first used to differentiate this type from the rectilinear woven type of splint or market basket. There are two principal types—those in which the sides and bottom are formed from continuous staves, and those made of short, noncontinuous staves and a separate solid or built-up bottom piece.



BAE 18681

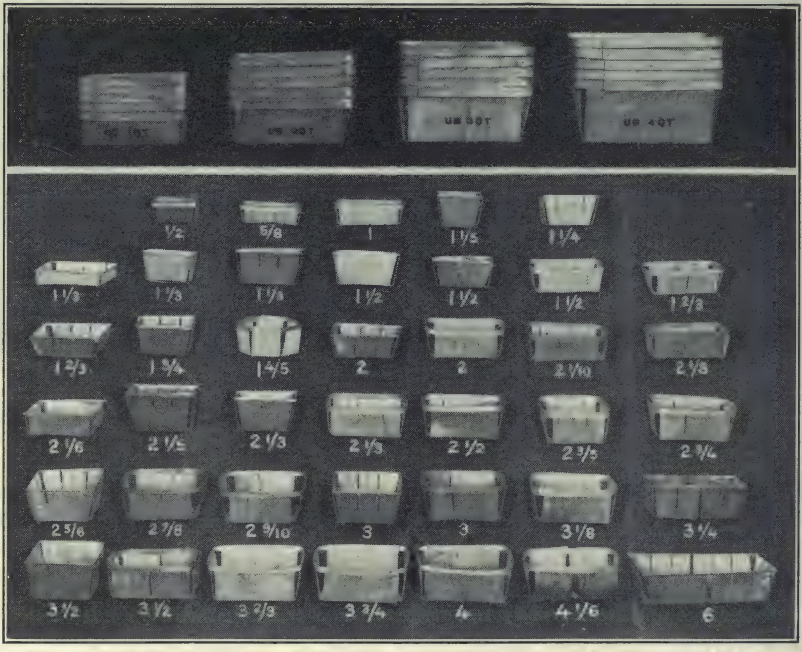
FIGURE 3.—Upper, United States standard ½-pint, 1-pint, and 1-quart berry baskets (American); lower, the Standard Container Act of 1916 eliminated many of these odd-sized berry baskets.

When made with only two outside hoops, one at the top and the other midway between the top and bottom, continuous stave baskets are usually called round bottom baskets, reflecting the curved nature of the bottom.

When a third hoop is placed at or near the bottom, the angle between the sides and bottom is more pronounced and definite, and the sides and bottom are, respectively, relatively straight and flat. Such baskets have been variously called bent bottom, straight side, flat bottom, tub, and other more or less descriptive terms. To simplify matters for administrative purposes, continuous stave baskets are classified as to the number of outside hoops—either two-hoop or three-hoop baskets. In the trade, the latter and all noncontinuous stave baskets, which of necessity are constructed with three, rarely four, outside hoops, are called tub baskets or simply tubs.

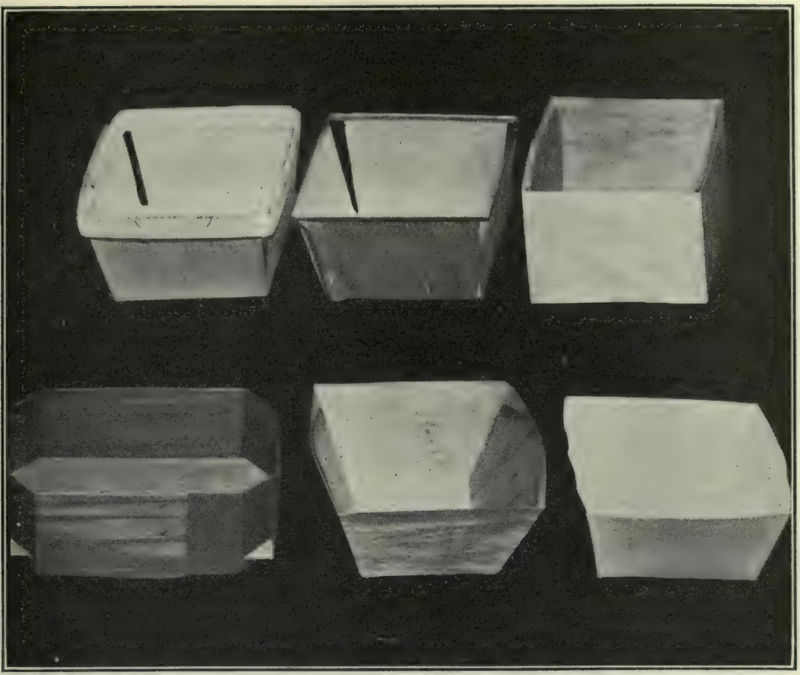
"A vessel of varying capacity made of flexible material, such as twigs, splints, or strips of metal, interwoven and commonly bound at the top" is the dictionary description of a basket. Of all the baskets used for fruits and vegetables the splint or market basket is the one that most nearly conforms to this definition, and the only one directly related to the oldest form of man-made container other than those made from the skins of animals.

Formerly manufactured in tremendous quantities and used over wide areas for fish and meat products as well as for the local marketing of fruits and vegetables, the old original diamond-weave basket with characteristic drop or rigid overhandle has been all but displaced by other types of containers except in a comparatively few and rather isolated areas. In the North Central States, for tomatoes, lettuce, celery, bunched vegetables, and similar products, it has been almost entirely supplanted by the improved square-braid or solid-veneer type



BAE 33109 AND 3287

FIGURE 4.—Upper, United States standard 1-, 2,- 3-, and 4-quart oblong till baskets; lower, before standard sizes were established in 1916, baskets of 30 different and changing sizes were in general use.



BAE 15880

FIGURE 5.—Six types of berry baskets—American, metal-rim, Hallock, Leslie, stitched tray, and paper.

of much greater strength and rigidity, which has proved satisfactory not only for local use but also for motortruck and rail shipments to distant points.

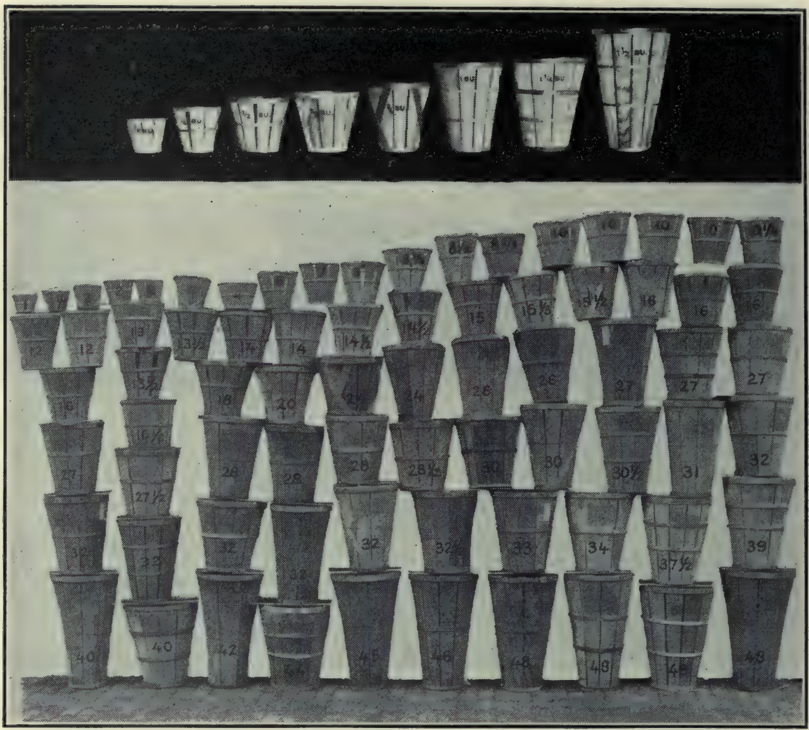
Six standard sizes are provided: 4-, 8-, 12-, 16-, 24-, and 32-quart (fig. 8). More recently paperboard baskets of the same general shape and design have become exceedingly popular in certain sizes and for certain products.

ENFORCEMENT OF THE ACTS

Rules and regulations for carrying out the provisions of the Standard Barrel Act were prepared by the Director of the Bureau of Standards, Department of Commerce, as the act is administered by that Bureau. They are published in Circular of the Bureau of Standards No. 71.

The two Standard Container Acts are administered by the Bureau of Agricultural Economics under rules and regulations promulgated by the Secretary of Agriculture, which are found in Service and Regulatory Announcements Nos. 104 and 116, Bureau of Agricultural Economics.

These three laws have done away with a large number of unnecessary and deceptive sizes of barrels, baskets, and hampers (figs. 1, 2, 3, 4, 6, 7, and 8), and the established sizes of each type are now largely made on standard or recommended specifications. At frequent intervals baskets and hampers are tested at each factory. By this means



BAE 18684

FIGURE 6.—Upper, standard hampers established by the Standard Container Act of 1928 (2-bushel size not shown); lower, these are 75 hampers of varying sizes and shapes that confused buyers and sellers before standardization.

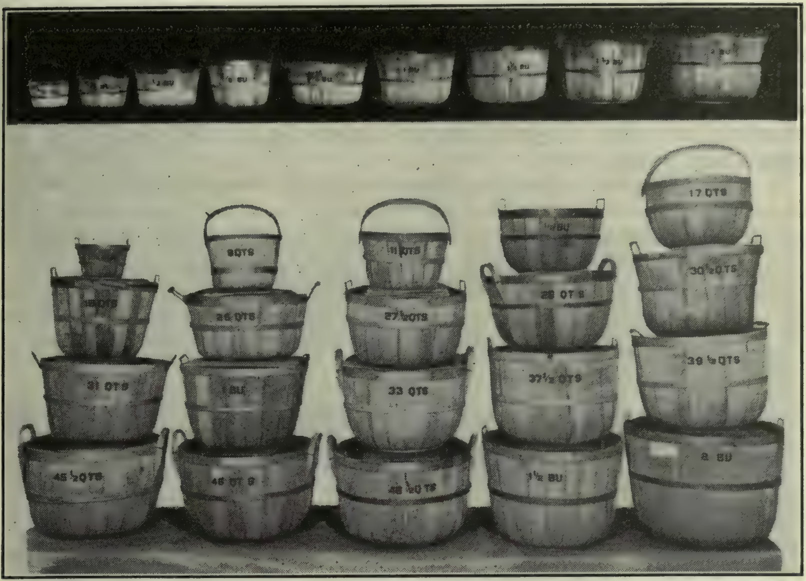
and with the cooperation of the manufacturers the public is assured of uniformly standard baskets and hampers, which it has now come to accept largely as a matter of course.

IMPORTANCE OF STANDARDIZATION

The average citizen has a greater interest in standard containers for marketing fruits and vegetables than he generally realizes. He is at all times a consumer of some commodity, and he may be a grower or shipper, a receiver, distributor, or retailer of other commodities. Or he may be a manufacturer of containers or an official of a transportation agency.

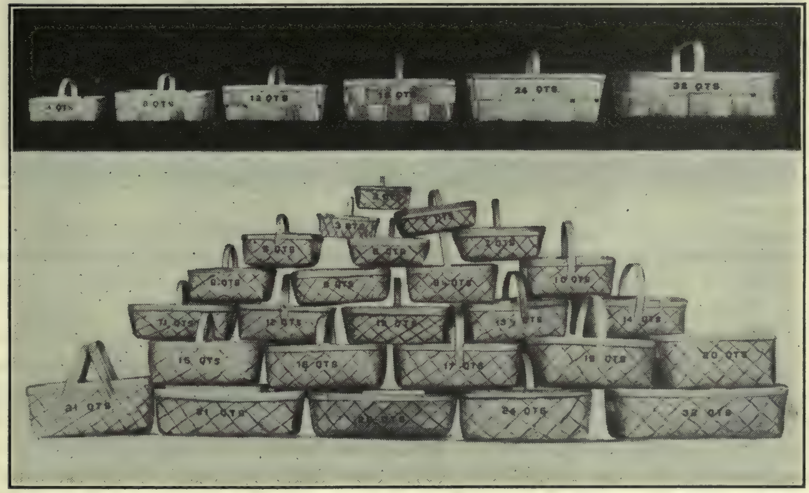
As a consumer he may be directly or indirectly defrauded by the substitution of a container of short-measure capacity at the full-measure price. He pays a part of the increased cost of marketing occasioned by the greater expense of manufacturing a large number of styles and sizes, and a part of the increased cost that is attributable to damage in transit which may be due to weak packages, to improper stowage, or to the difficulty of loading odd-sized containers.

The grower or shipper benefits from any action that lowers the cost of packages, that tends to reduce damage in transit, and that provides


8 QTS
11 QTS
17 QTS
26 QTS
27½ QTS
28 QTS
30½ QTS
31 QTS
1 BU
33 QTS
37½ QTS
39½ QTS
45½ QTS
46 QTS
1½ BU
2 BU

BAE 18678

FIGURE 7.—Upper, nine standard sizes of round stave baskets; lower, before standardization: only 2 of these 20 baskets are the same size.


8 QTS
12 QTS
24 QTS
32 QTS
15 QTS
16 QTS
17 QTS
20 QTS
24 QTS
32 QTS

BAE 5272

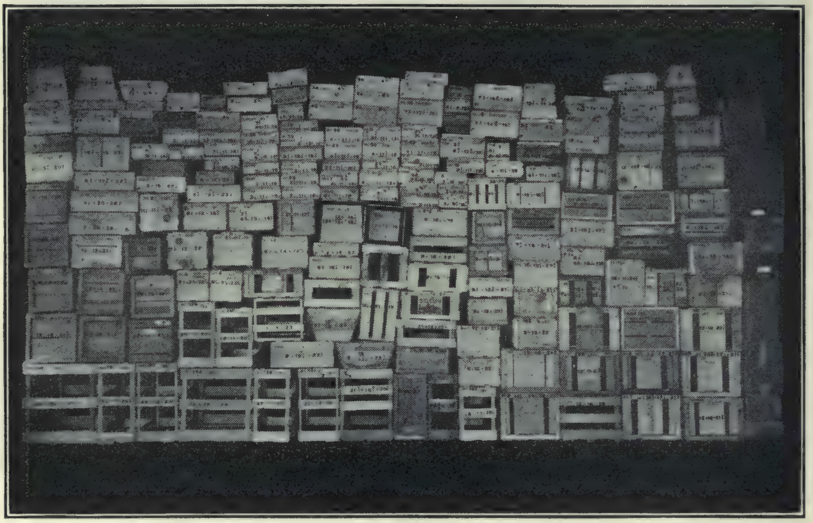
FIGURE 8.—Upper, six standard sizes of splint or market baskets (square braid); lower, in 1928 most splint baskets were of the diamond-weave type. Both over-handle and drop-handle types were widely used. Many sizes other than the 21 shown were in common use.

him with a definite basis of sale and market information so far as the size of package is concerned. Standard containers relieve him from the unfair competition of a competitor who might otherwise use a short package.

To the manufacturer standardization of containers means that production is simplified and that he can concentrate on and carry in stock relatively few sizes, with consequent lowering of manufacturing, handling, and storage costs.

To the carrier it means the elimination of many sizes that now contribute to the problem of damage in transit and narrows the problem to a few sizes for which standard strength specifications can be worked out and approved methods of stowage and bracing devised.

The confusion caused by the use of innumerable and deceptive sizes and types of containers for which standards have not been established is held by the receiving and distributing trade to constitute an unnecessary burden upon the industry.



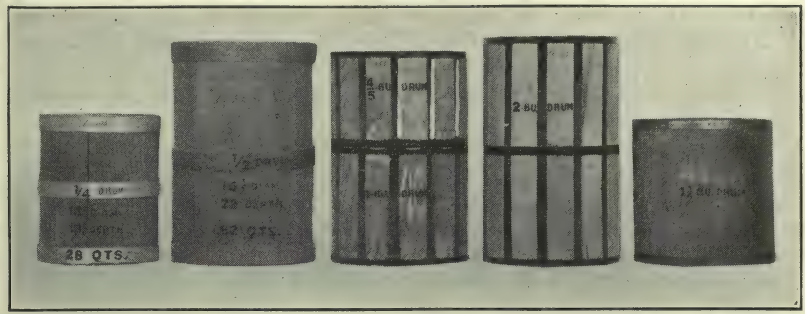
BAE 30179

FIGURE 9.—Exactly 198 different types and sizes of crates, boxes, and cartons used for fruits and vegetables in 1934. Some simplification and standardization should be possible.

NONSTANDARDIZED CONTAINERS

Although laws have now done away with a large number of unnecessary sizes of baskets and hampers, and a similar degree of simplification was probably accomplished in the case of barrels, there remain two great classes of containers for which no Federal standards have been established and to which it is generally believed that the principle of standardization could be applied with equally beneficial results, as the use of such containers of innumerable and deceptive shapes and sizes imposes a tremendous burden on the fruit and vegetable industry (fig. 9).

These two classes—crates and boxes, and sacks—are used in far greater volume for fruits and vegetables than are baskets, hampers, and barrels. Exact figures are unavailable, but it has been estimated that approximately 10 percent of the total annual movement of fruits and vegetables is shipped in bulk, 20 percent in baskets and barrels, 20 percent in sacks, and the remaining 50 percent in crates and boxes. To the limited extent that drums are used, they constitute a third class for which there are no Federal standards. In slatted form these containers are sometimes referred to as cylindrical crates (fig. 10).



BAE 33842

Figure 10.—Drums. From left to right: ¼ and ½ drums for California brussels sprouts; ⅘-, 1-, and 2-bushel drums for citrus fruits, potatoes, etc.; California grape drum.

It is erroneous to infer that no simple standards exist for these containers. As a matter of fact many of the crates, boxes, and sacks used for fruits and vegetables have become virtually standard through common usage. Many States have established standards by law or regulation, but the unfortunate lack of uniformity in the provisions of these laws and their permissive nature tend to minimize the beneficial results sought.[1]

Largely through the forward-looking action of the manufacturers and the cooperation of the shippers and receivers, the sizes of sacks used for fruits and vegetables have been effectively reduced in number. For some products odd-sized sacks may still be used in certain localities, but the 50-pound sack for onions and the 100-pound sack for potatoes have become well established as standard merchandizing units in the principal producing sections.

Certain containers have become about as well standardized through common usage as they could be by national regulation. Among these are the Northwest apple and pear boxes, the western cantaloup crates, the California citrus-fruit box, and some portion of those used in Florida and Texas, certain carrier crates like the four- and six-basket crates, berry crates, and perhaps some others. The carrier crates vary in dimensions, but the cups used in them are of established standard sizes.

Another group of crates and boxes approaches but fails to attain, a similar status, perhaps because they are manufactured for use in several producing sections for several different products. These products are usually packed and sold by weight or count but for some real or fancied reason seem to require containers of slightly varying dimensions. Among the more important of these general-utility containers are the western-type lettuce crate and half crate used throughout the West and South, and in some other sections, for lettuce, bunched carrots, beets, turnips, cabbage, and similar products; the eastern-type lettuce crate; and the southern-type pepper crate used in the South for many of the products named above and also for peppers, eggplant, beans, greens, broccoli, squash, etc.

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[1] The provisions of State and Federal laws pertaining to containers for fruits and vegetables are summarized in a mimeographed circular issued by the Bureau of Agricultural Economics.

Included among the general-utility containers is the western-type peach or fruit box used for many western tree fruits, and the so-called Los Angeles lug, which is now virtually the universal package for tomatoes, a predominate package for California grapes, and an extensively used container for western pears, plums, prunes, apricots, pomegranates, and cherries.

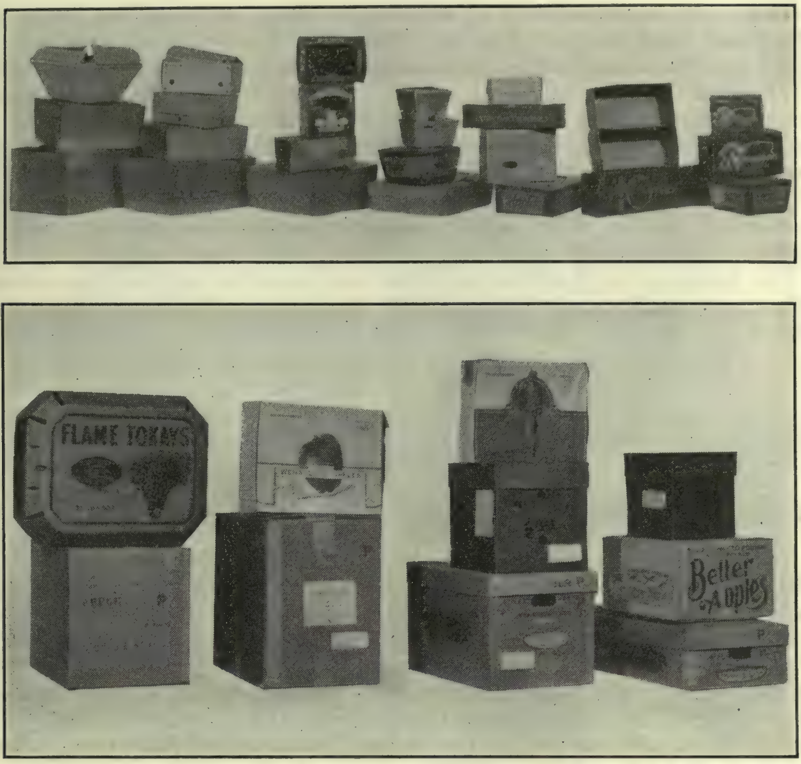
Observations seem to point to the increasingly wide use of these containers, their conformity to distinctive patterns, and the predominance of certain specifications. For a large part of the products commonly packed in them it would seem that these general-purpose containers could be manufactured nationally on common specifications.

The remaining relatively small portion of the crates and boxes are those used for special products varying in their nature and varietal and regional characteristics and requiring containers more or less especially designed as to size and shape. Among these products are asparagus, celery, cherries, and perhaps some others, universally packed and sold by weight or count. Recognition of the peculiar regional requirements of some of these products may preclude standardization of the containers on a Nation-wide basis, but in such instances that may be secondary to the establishment of definite and distinguishing local standards and their proper designation.

One of the most recent developments in the packaging of fresh fruits and vegetables is the use of containers made of solid fiberboard or corrugated paper. In certain instances this use is already appreciable, and because of the adaptable nature of these materials it is not unreasonable to expect even wider use of containers made of them. These containers now come in a variety of confusing shapes and sizes, and they sometimes present an administrative problem in classification. Some of them (by reason of shape, size, construction, and usage) may be definitely called baskets and as such are required to comply with the capacity requirements of the Standard Container Acts. Others may just as definitely be classified as boxes and are subject to no Federal regulation—for convenience these are called cartons. But certain paper containers do not seem clearly to fall in either of these two distinct classes, and so they create a highly unsatisfactory administrative situation as well as a confusing marketing condition (fig. 11).

Although they are of minor importance from the standpoint of the total annual movement, the extent to which cartons, crates, and boxes are used for products sold by the bushel (that is, by volume or by measure) seems to be increasing and is one of the least satisfactory aspects of present-day marketing and distribution of perishables.

These containers, being units or instruments of measure, perform precisely the same function as baskets and barrels, the standardization of which has been deemed to be in the best interest of the public.



BAE 33840 AND 33841

FIGURE 11.—Some paper containers for fruits and vegetables are typically boxes (cartons). Others are classed as baskets, and some are difficult to classify. (See also fig. 53.)

SOME CAUSES OF VARIATION

Regional packages are among the important factors contributing to confusing market conditions. Such packages may have been satisfactory when their use was confined to a limited territory but as modern methods of transportation bring products from every corner of the country into the great marketing centers, the diversity of styles and sizes of containers means unnecessary and costly confusion.

The numerous crates and boxes which are especially designed for certain products packed by count or weight, and which reflect at once the varying varietal or regional characteristics of the products, varying grades and sizes, varying stated quantities and methods of packing, and not infrequently merely local pride or prejudice or the desire of some shipper to use a package different from any other, constitute a class separate and distinct from those containers that are units of measure or volume. Hence they must be considered from entirely different angles. The necessity for special containers for certain products is generally recognized, but the need for them in the present multiplicity is seriously questioned.

The unfair competition of short-measure containers has been another confusing factor. Certain shrewd packers have found that by slight modifications in the shape of packages the cubical contents can be reduced substantially without noticeably affecting the appearance. Commodities sold in these containers can be offered at a lower price per package than those sold in standard packages, but the price per unit of weight is really higher. Often this has caused the general adoption of the short-measure package; and there is no end to this procedure, for once the short measure becomes established, a still shorter one is put out by the unscrupulous minority.

The lack of a unit that is accepted as the basis for all package standards adds many unnecessary packages. If a manufacturer wishes to introduce a crate into a section that now uses the barrel, instead of introducing the bushel unit, the tendency is to offer a barrel crate or a half-barrel crate. At present, crates and boxes are being manufactured in sizes based on the United States standard barrel (105 quarts) with its subdivisions, the United States cranberry barrel, the weight bushel, the heaped bushel, and the volume bushel.

NEED FOR A FIXED UNIT AS A BASIS FOR STANDARDIZATION

For containers that determine the quantity of contents of products sold by measure or volume the dry quart with its subdivisions and multiples is a satisfactory basis for standardizing such small containers as the berry box and small till basket, but for larger packages a larger unit is necessary so that the customer can recognize readily the various sizes. For this purpose the Winchester or struck bushel, containing 2,150.42 cubic inches, is believed to be the most satisfactory unit. The weakness of adopting arbitrary standards has already been shown as one cause of unsatisfactory conditions.

A standard unit of measure should be permanent and definite and of fixed and uniform value. The heaped bushel that has sometimes been used is far from being fixed. A proper heap has never been defined by Congress, and in those States where an attempt has been made to describe it the phraseology generally is indefinite. The heap has been referred to as a cone, the base being the top of the measure, and the height depending on the nature of the article when piled "as high as may be without special effort or design." Such vegetables as sweetpotatoes under this definition might be piled so high that the heap would be as large as the measure itself.

Many States have attempted to define the bushel in terms of weight. But, if the bushel is at the same time to be regarded as a unit of volume this is impossible, as the weight of any given volume of fruits or vegetables will vary with the size, variety, and condition of the product and the tightness of the pack.

It is not clear just what was the basis for the weight-per-bushel laws that are now in effect, and wide differences may be found in the laws of the various States. To illustrate, the legal weight per bushel of sweetpotatoes is 46 pounds in North Dakota and 60 pounds in Maryland. In 14 other States it is 50 pounds, in 10 States 54 pounds, in 5 others, 55 pounds, and in still 5 others it is 56 pounds. Similarly the legal weight per bushel of unshelled green peas is 26 pounds in Connecticut and 56 pounds in Missouri. A bushel of tomatoes is 45 pounds in Oklahoma and 60 pounds in Virginia. If the various States were to enforce rigidly these weight-per-bushel laws, interstate commerce certainly would be carried on under tremendous difficulties (fig. 12).

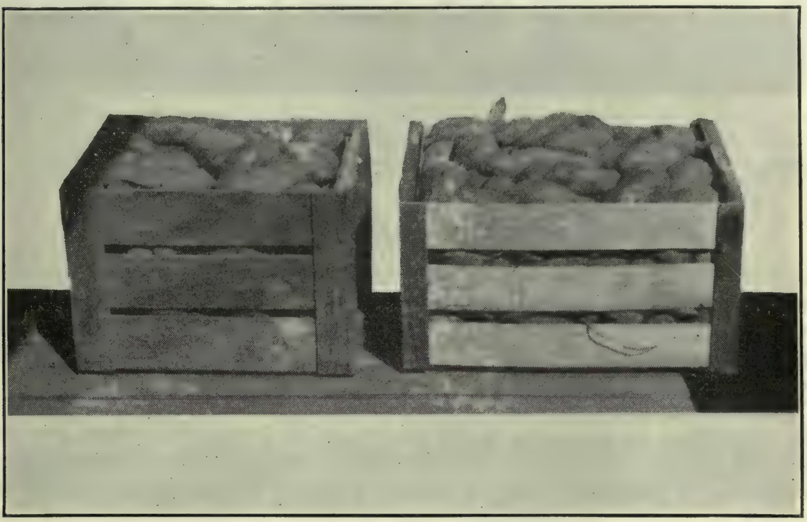
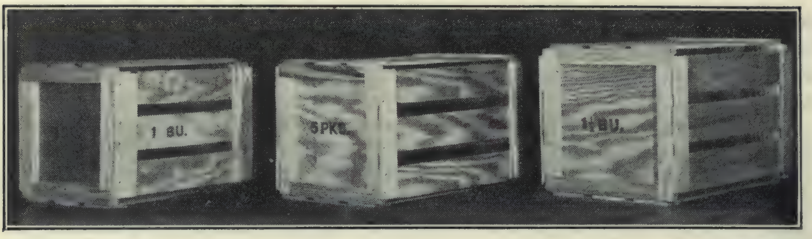


FIGURE 12.—Two well-filled crates: Left, 1-bushel crate (12 by 12 by 15 inches inside) contains 51 pounds net of sweetpotatoes; right, crate designed to hold a "weight" bushel contains 58 pounds net of sweetpotatoes. Neither weight conforms to the legal weight per bushel of any State.

The most satisfactory unit for standardizing containers used for products sold by measure is the Winchester bushel of 2,150.42 cubic inches, first recognized in 1836 through a resolution of Congress authorizing the Secretary of the Treasury to prepare a set of standards for use in the customhouses and for other purposes. The Treasury Department adopted the Winchester bushel and most of the States now recognize this standard by legislative enactment. The Standard Container Act of 1928 prescribing the standard sizes of hampers, round stave baskets, and splint baskets defines a bushel as containing 2,150.42 cubic inches.

A package based on this fixed unit of volume, when filled level with the top, is easily recognized as full measure, and any variation or slackness in filling is at once detected even by the untrained eye.

Containers for products sold by measure, whether baskets or crates, should be such as to be readily identified and differentiated from any other, and should be correlated as to size. Otherwise on a competitive market there can be no fair comparison of values. Containers based on arbitrary standards afford an opportunity for the unscrupulous dealer to take unfair advantage of both the buyer and seller (fig. 13).



BAE 2189A

FIGURE 13.—Packages based on the standard bushel and its usual subdivisions and multiples are readily identified and differentiated. Any variation or slackness in filling is readily detected.

SALES BY MEASURE VERSUS SALES BY WEIGHT

Of the three methods by which fruits and vegetables are commonly sold—by measure, weight, and count—it is generally recognized that weight is the most definite basis of sale although, for products carefully graded to standard sizes, sale by numerical count is considered equally satisfactory.

It should be borne in mind, however, that most fruits and vegetables are marketed in package form and that the trend continues to be toward smaller packages better suited to modern merchandising methods. Obviously, only a small part of these products can be graded to standard sizes and sold by count. For obvious reasons, also, transactions involving the sale of packed containers often cannot be made on a net-weight basis without adding greatly to the cost of marketing. Many sales are made while the products are in transit to market, and even if the weight at time of packing were known, a considerable variation from this weight might occur as a result of shrinkage or decay. Then, too, a shipping package must be filled compactly without regard to weight, or the product may be damaged by movement within the container. Under such conditions any designated weight must necessarily be more or less arbitrary and hence not accurately informative, and the time and labor required to weigh each package might more than offset the good to accrue from a knowledge of the exact weight.

Unless the weight shown on a package accurately represents the actual weight of the contents, it serves no protective purpose other than to indicate the approximate quantity; and when containers of closely related varying sizes and shapes are used, accurate marking may be bewildering if not actually misleading because the ordinary person cannot judge readily quantities that vary by small amounts.

Moreover, the character of the contents is usually of as much consequence to the customer as is the quantity, and most fresh fruits and vegetables are now bought and sold on the basis of established Federal or State grades. In some instances, for products packed and sold by weight or count, standard packs—charted arrangements of the individual fruits or vegetables comprising the pack—indicating both the character and the quantity of the packed product, have been set up, sometimes as a part of the established grades. Manifestly, such a standard pack must be based upon the use of a standard and uniform container.

Thus the conclusion seems inescapable that in the case of most packaged goods the expeditious handling of fresh fruits and vegetables and adequate protection for the buyers and shippers lie in the use of standard packages whereby the quantity or character of the contents, or both, can be most easily and fairly evaluated largely on the basis of fill.

Massachusetts was the first State to recognize the existence, economic importance, and indispensability of standard containers for fruits and vegetables. In 1922 they were given legal status in that State in the following words: "Except when sold in the original unbroken standard container all fruits, nuts, vegetables, and grain shall be sold at retail by avoirdupois weight, or numerical count." The term "original unbroken standard container" was defined as including barrels, boxes, baskets, or similar containers the capacity of which had been established by Massachusetts or Federal law, properly marked as to net contents in terms of weight, measure, or count, and from which the contents had not been removed and had not been repacked.

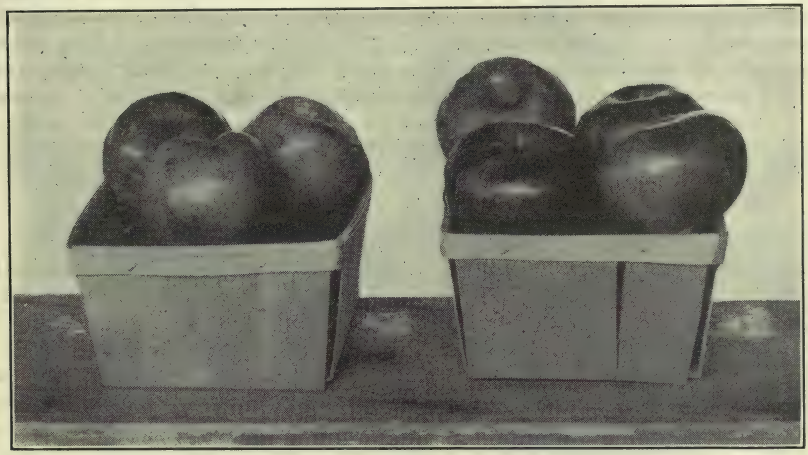

BAE 2647

FIGURE 14.—Misuse of a standard basket. Quart berry baskets are intended only for the marketing of berries and similar small fruits. There is a variation of 14 percent in the weight of the apples in the two baskets in this picture.

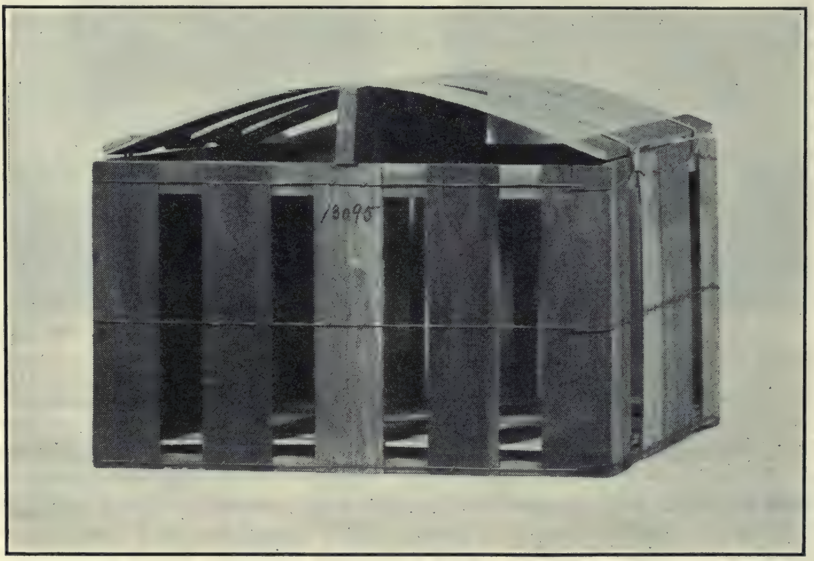
The standard of measure for dry commodities has been established by the same competent authority which established standards of liquid measure and standards of length and weight. Misuse or abuse of those standards does not nullify their integrity, and proper performance of their functions and purposes depends upon continuous supervision and regulation. Modern trade and commerce employs merchandising units based on one or another of these standards for an infinite number and variety of products (fig. 14).

Whether such units are sound and suitable depends on the peculiar conditions and factors in each instance. Thus, whether the sale of fruits and vegetables should be by weight, measure, or count depends on varying factors. In general it may be said that the sale of packed fruits and vegetables in the original standard container should be by the package, but when such containers are broken in order to dispose of the contents in smaller quantities, sales should be made by weight or numerical count.

PROPER FILLING

It is greatly to the advantage of all parties interested in marketing fruits and vegetables that, in addition to fixed standards for containers, proper methods of filling be employed. If containers are not well filled the waste space increases the package cost. As freight charges are ordinarily based on an estimated per package weight, the carriers receive pay for more than they actually carry when the containers are not full. Moreover, the product is likely to be shaken and bruised in transit and then discriminated against by dealers in the markets on account of its poor appearance.

To avoid slack filling and to insure a full pack at destination it is customary to pack fruits and vegetables with a bulge above the top of the container. The cover is then put in place by pressure. When the height of the pack is not excessive this is a desirable practice, as it prevents damage due to movement within the package. The extra quantity of produce is more than paid for by the ready sale and better price that is obtained for an attractive pack. But in recent



BAE 25095

FIGURE 15.—Crate designed for overpacking. The rated capacity of this crate is 76 quarts. The bulge provided by the oversize cover amounts to approximately 9 quarts. Practically 11 percent of the contents is outside the package.

years bulge packing has degenerated into overpacking and has been carried to extreme and indefensible lengths. Whether reflecting attempts to take unfair advantage of estimated per package weights established by the carriers, or to obtain some quantity more than is actually paid for, overpacking has become one of the most serious and costly evils of present-day fruit and vegetable marketing (fig. 15).

CONTAINERS COMMONLY USED

The containers used for shipping a given commodity may vary widely in different sections of the country. One section may use a basket, another a crate, a third a barrel, a fourth a sack. The increase in the production of fruits and vegetables and in the interstate movement of these products, the development of new producing areas, the introduction of new types of containers, the penetration into one section of the types of containers popular in another section, and the keen competition between the many producing sections and container manufacturers, have stimulated interest on the part of farmers in the containers used throughout the country for the kinds of fruits and vegetables they grow for shipping.

It is impossible to mention all of the different containers that may be used in different sections at different times. In many instances no particular container predominates for some commodities—whatever is handy is used. Fruits and vegetables taken into city markets by nearby farmers may move in a variety of containers. For instance in one New England city spinach was found on the market in lettuce crates, egg cases, orange boxes, and hampers. In this bulletin an effort will be made to mention the containers most favored by the important shipping sections.

APPLES

The three principal containers used for the shipment of apples are the barrel, the box, and the basket. For certain tender varieties like the McIntosh, as grown in New England and the Hudson River Valley, cartons of the cell type are used to some extent, and some cartons without cells are used in other sections. California has established a standard fiberboard apple box and half box with dimensions somewhat different from those of the wooden boxes. Some experimental shipments of apples in small consumer-size bags have been reported from the Northwest, but by far the largest volume of the commercial crop moves in the three types of containers mentioned.[2]

The barrel, formerly the popular package in the eastern part of the country, has, for the domestic market, been all but supplanted by baskets, and more recently by crates. For export purposes the barrel is still considered a superior package.

The northwestern apple box (fig. 16) has been standardized by law in the following States: California, Idaho, Kansas, Montana, New Mexico, Oregon, and Washington in the West; and in the District of Columbia, Maine, Massachusetts, Vermont, and Virginia in the East. Although, as in California, under certain conditions other boxes are occasionally used, the northwestern apple box is the one thought of when an apple box is mentioned. The box is also used for shipping quinces.

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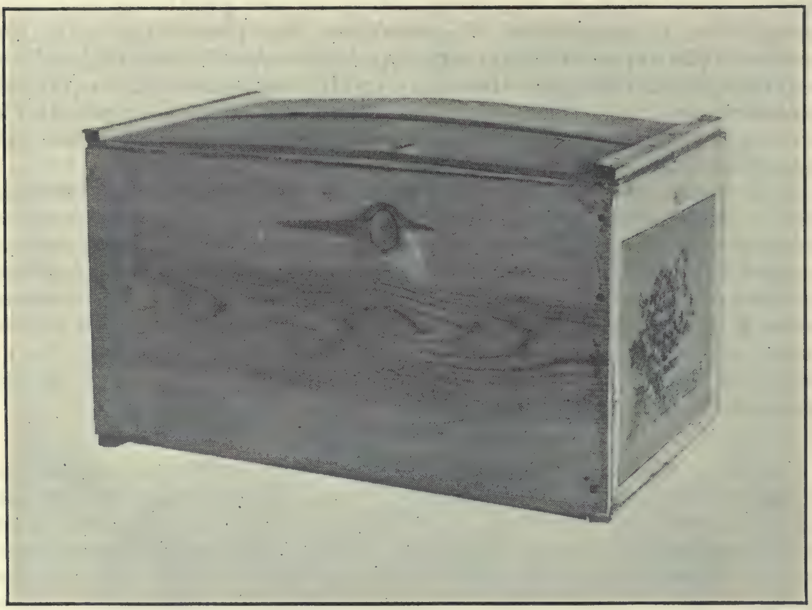
[2] The preparation and packing of apples for market are discussed in detail in Farmers' Bulletins Nos. 1457, Packing Apples in Boxes, and 1695, Preparing Apples for Market in Barrels and Baskets.

The inside dimensions of the northwestern box are 10½ by 11½ by 18 inches, giving it a content of 2,173.5 cubic inches, or 23.08 cubic inches in excess of the United States standard bushel of 2,150.42 cubic inches. As this is well within the excess tolerance of 50 cubic inches allowed for a bushel container under the United States Standard Container Act, this box may be considered a bushel container.

Slight variations are found in the thickness of the ends, sides, tops, and bottoms. These variations are largely due to the manufacturer's wish to cut as economically as possible the stock from which the shook is made up. Thus, ends may be 11/16, ¾, 25/32, 13/16, or ⅞ inches thick, and to maintain an inside length of 18 inches, the length of the sides, top, and bottom vary proportionately from 19⅜ to 19¾ inches. Allowing for these minor variations, the northwestern apple box is the same in inside width and length as the commonly used peach and pear boxes of that territory.

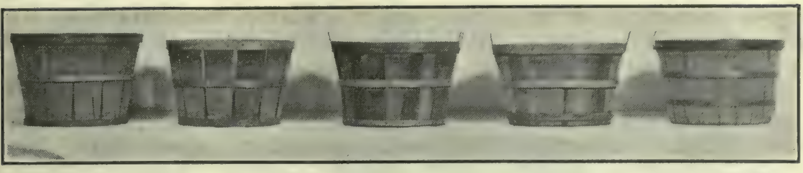


BAE 6382

FIGURE 16.—Universally accepted standard northwestern apple box.

In the East this box is sometimes made with paneled ends, and, in order to maintain an inside length of 18 inches, the outside length is more nearly 20 inches.

The baskets most commonly used for apples are the 1-bushel round stave, straight-side, or tub type, of which there are several styles (fig. 17). The growth in popularity of the basket followed the development of the various types of straight-side baskets and the introduction of ring-packing devices. When properly strapped, straight-side baskets have proved feasible for export shipments, particularly those constructed with solid or built-up bottoms.



BAE 25124

FIGURE 17.—Tub baskets—raised bottom, solid bottom, and three styles of continuous-stave three-hoop baskets.

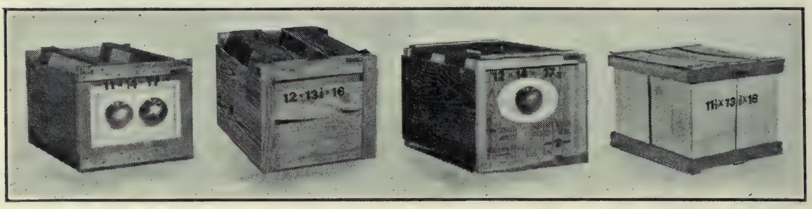
Formerly 1-bushel hampers with removable bottoms were commonly used for apples in Delaware, Maryland, and New Jersey. With this type the cover was placed in position, the hamper turned bottom up, and the fruit ring-packed through the bottom end. The bottom was then forced into place and nailed in. One type of straight-side basket is made with a removable bottom and is packed in the same way.

The most recently developed container to become popular with eastern apple growers is the so-called northeastern apple crate, a package which was designed primarily for the storage and transport of McIntosh and similar tender varieties grown in New England and the Hudson River Valley sections but which in various forms has come into use for all varieties over wide areas. For its original purpose the crate was made oversize so that it would hold the desired quantity, jumble-packed, with but slight rearrangement of the face. Such crates were constructed with ends extending above the sides so that they could be stacked in storage or in trucks or cars without brusing the contents. Except for two narrow slats across the top as insurance against shifting, these crates as first used were open, returnable containers.

This package received its name and came into prominence about 1934 as a result of local cooperative efforts to establish a crate of standard size and dimensions to replace the many different-sized crates then being used and to provide a uniform basis for market quotations. Although crates varying in size from 1 bushel to nearly 1½ bushels were being used, the committee in charge disregarded both of those two standard sizes and the one in between, 1¼ bushels, and adopted as standard a crate based on a contemporary standard package of an entirely different type but upon which the current practice superimposed a bulge or crown pack.

In other words, the standard adopted for the northeastern crate was the heaped bushel—an indefinite and undefinable quantity. The inside dimensions of the crate adopted as standard for New England were 11 by 14 by 17 inches, or if triangular corner posts were used, 11 by 14 by 17½ inches, and the capacities were 2,618 and 2,645 cubic inches, respectively. A few months later a crate with a capacity of 2,616 cubic inches and of somewhat different dimensions (12 by 13⅝ by 16 inches, inside) was adopted by growers in western New York.

The crate was not long used as a jumble-pack, partly filled, open, returnable container. Almost immediately after its adoption in New England the demand arose for full, faced packs, and full closure. Thereupon crates of many sizes and dimensions came into use, variously marked "1 Bu.," "1⅛ Bu.," "1⅙ Bu.," "1⅕ Bu.," "1¼ Bu.," etc. Figure 18 shows a number of different types and suggests the confusion likely to result from the adoption of arbitrary standards.



BAE 33861

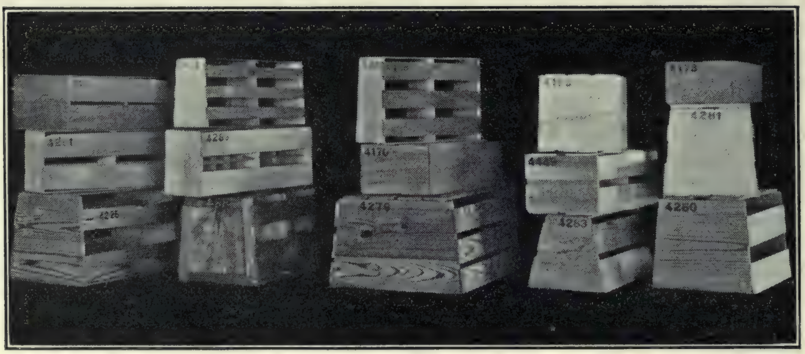
Figure 18.—Eastern apple crates, 1937. From left to right: So-called northeastern apple crate, 39 quarts; crate adopted by western New York and Ohio growers, 38½ quarts; crate used by one large Virginia shipper, 41 quarts; crate used by a large Michigan shipper, 35½ quarts.

ARTICHOKES

Artichokes are commonly shipped in either of two boxes both standardized by California law—the full-sized box measuring 9¾ by 11 by 20⅝ inches, and the half box 4⅞ by 11 by 20⅝ inches, inside.

ASPARAGUS[3]

Of necessity asparagus must be marketed in special crates or boxes (fig. 19), and to accommodate its tapering nature the pyramidal-type crate is used, either exclusively or to some extent, in all important producing sections. The California standardization law provides for two slightly different crates, one 10 inches and the other 11 inches deep. Both crates are 18 inches long inside and the tops, ranging from 9 to 10 inches wide, are the same in both, but at the bottom the deeper crate is only 11 inches wide as compared with 11½ inches in the shallower 10-inch crate. These crates have two compartments, and although usually packed with twelve 2-pound bunches they are sometimes used for loose asparagus.



BAE 13948

Figure 19.—Various types of asparagus crates.

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[3] The preparation of asparagus for market is discussed in Farmers' Bulletin 1646, Asparagus Culture.

The crate used in South Carolina and Georgia is similar to the California crate, measuring 11 inches (depth), 9½ inches (top), 10½ inches (bottom), and 17¾ inches (length, inside). But in early-season shipments, narrower crates 12 and 13 inches in depth are sometimes used.

The one-dozen size crate has practically supplanted the two-dozen size crate formerly used in New Jersey, Delaware, Maryland, and Pennsylvania. In Delaware, three crates are reported as usual. One is 10 inches deep, 9½ inches at top, 12½ inches at bottom, and 15½ inches long, inside. Another, having the same length, is 11 inches deep, 9 inches at the top, and 13 inches at the bottom. The third has the same depth and top width as the second but is only 12 inches wide at the bottom and 15 inches long. Otherwise, in this section, typical crate dimensions are 10¾ inches, depth; 10½ inches at the top; 12 inches at the bottom; and 16 inches, inside length. The variations reflect natural differences in the character of the stalks and in the way of trimming and packing the asparagus.

The section around Kennewick, Wash., formerly marketed its asparagus packed loose in a two-compartment flat crate with the tips toward the center partition. At present most commercial shipments from Washington originate at Walla Walla and Bingen, and one-compartment pyramidal crates are used. At Walla Walla 12 pounds of loose asparagus is packed in a crate measuring 7¼ inches (depth), 5½ inches (top), 9½ inches (bottom), and 12 inches (length) inside. In the Bingen section a larger crate is used, approximately 9½ inches in depth, 5½ inches at top, 7½ inches at bottom, and 18 inches in length, inside. The dimensions of the crate established by Oregon regulations are depth, 10½ inches; top, 8 inches; bottom, 10½ inches; and length, 18½ inches.

A rectangular-compartment crate holding 24 bunches, and another holding 20 bunches, one bunch to a compartment, is used at Anna and Cobden, Ill. At Godfrey, a pyramidal crate 10 inches deep and holding 12 variously sized bunches is used, while at Ottawa a relatively shallow pyramidal crate for twenty-four 1-pound bunches is used. Splint or market baskets are sometimes used for asparagus in Ohio.

AVOCADOS

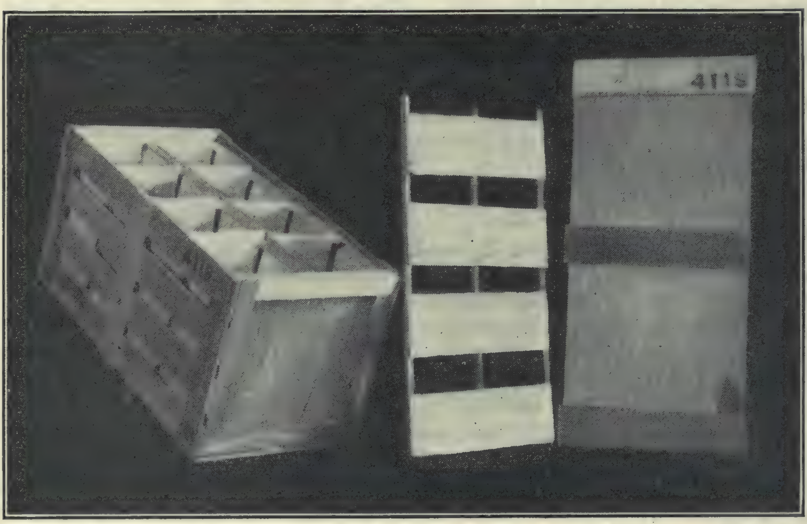
The shipment of avocados has been almost entirely by express, and at one time refrigerator crates were used for those shipped from Florida. At present, both Florida and California pack the larger sizes in single-layer flats. In Florida the crate ranges from 3¼ to 4¼ inches in depth by 13 inches wide by 15 inches long, inside. The California flat ranges from 3½ to 4½ inches in depth by 13½ by 16⅛ inches. The typical Los Angeles tomato lug of the same width and length but 5¾ inches deep is used for two layer packs of the smaller sizes.

BEANS

Practically all green beans are shipped in hampers (fig. 6). There is considerable difference of opinion in various sections as to the best size of hamper to use for beans. Florida and Mississippi and some other parts of the South formerly used the 28-quart hamper, believing any larger size to be too large. Under the Standard Container Act of 1928 this size became illegal on November 1, 1929, and since that date growers have used either the 24-quart or the 32-quart size. The North Carolina and Virginia sections use the 40-quart hamper. New Jersey uses the bushel size, which has come into use on the Pacific coast as the principal container for beans.

BERRIES[4]

Berries of all kinds are packed in ½-pint, 1-pint, and 1-quart baskets known as boxes or cups, the sizes of which are fixed by the Standard Container Act of 1916; crates are used only as secondary shipping containers for the cups. There are several distinct and more or less regional types of cups (fig. 5). The American type, manufactured throughout the East, South, and Middle West, is used over a wider territory and in greater quantity than any other. Raised-bottom Hallock cups are manufactured and used in the Lakes States and in the Pacific Northwest. The use of the Leslie type is confined to a small section in the Southwest, and that of the stitched tray to one or two cities in Missouri and Utah. Metal-rim cups are manufactured only in the East and the far West, but they are used in quantities second only to the American type for many diversified products throughout the country. Paper berry boxes were formerly considered as a separate type, but they are now made on the general lines of, and are largely interchangeable with, the American and metal-rim types. They are manufactured and used in the greatest quantity in California.



BAE 13008

FIGURE 20.—Typical 24-quart American berry crate. The 16-quart size is only two layers deep.

Special crates have been developed to fit the several types and sizes of cups. Unfortunately there is considerable variation in the dimensions. In the eastern sections of the country the crates generally used hold 24 pints, 16 quarts, 24 quarts, and 32 quarts (figs. 20, 21, and 22). A crate holding 36 oblong pint cups (fig. 23) is used in New Jersey and has become predominant in Florida. Typical inside dimensions of the crates in most common use in the East are given in table 1.

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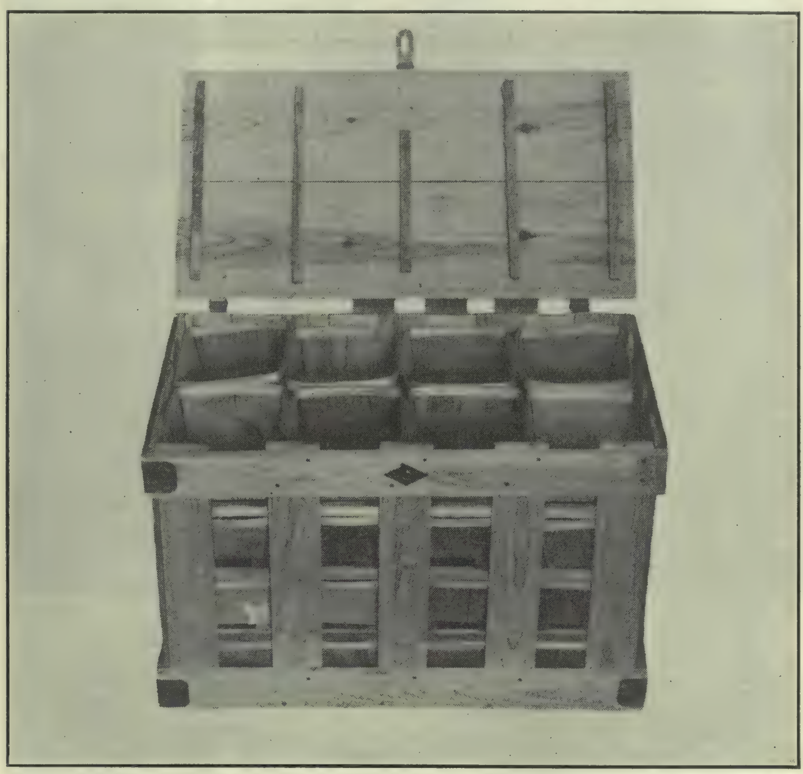
[4] The preparation of strawberries for market is discussed in Farmers' Bulletin 1560, Preparing Strawberries for Market.



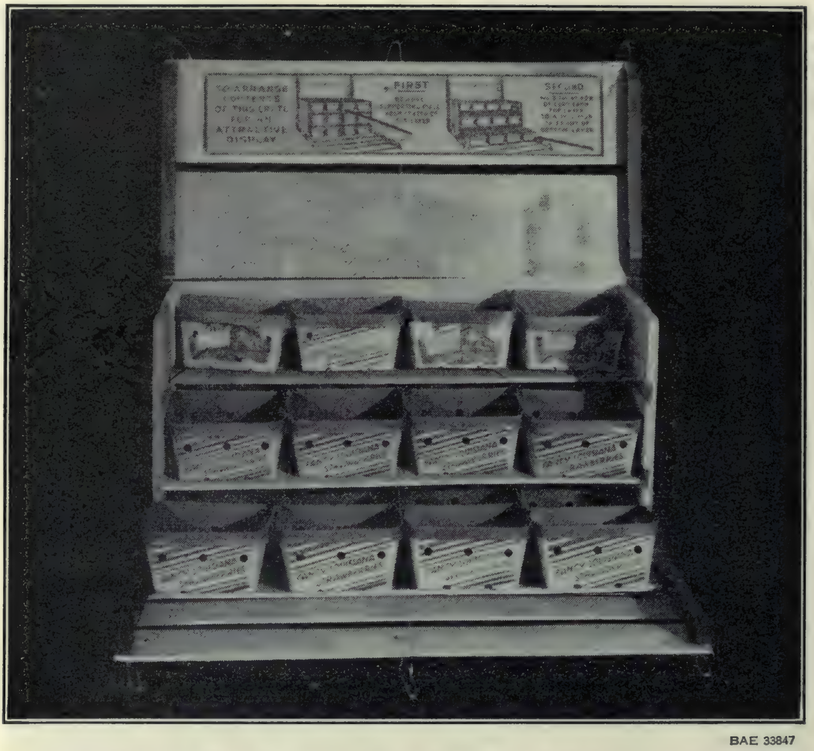
BAE 6011

FIGURE 21.—A 32-quart American berry crate with hinged top.

TABLE 1.—*Typical American-style berry crates*

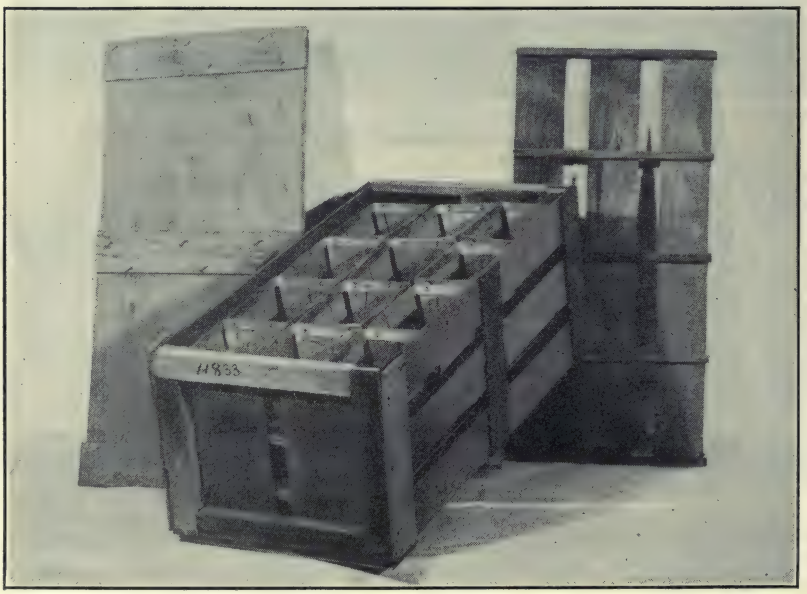
Capacity and type	Inside dimensions (inches)	Length of slat
		Inches
24-pint	9 by 9 by 18	20
16-quart	7¼ by 11 by 22	24
24-quart	11 by 11 by 22	24
32-quart nailed top	14¾ by 11 by 22	24
32-quart hinged top	14⅞ by 11 by 22	23⅛
36-oblong pint [1]	9 by 11 by 22	24

[1] Except that 1 is oblong and the other square, oblong cups and American cups, characterized by slanting sides, are structurally very similar.


FIRST
SECOND

BAE 33847

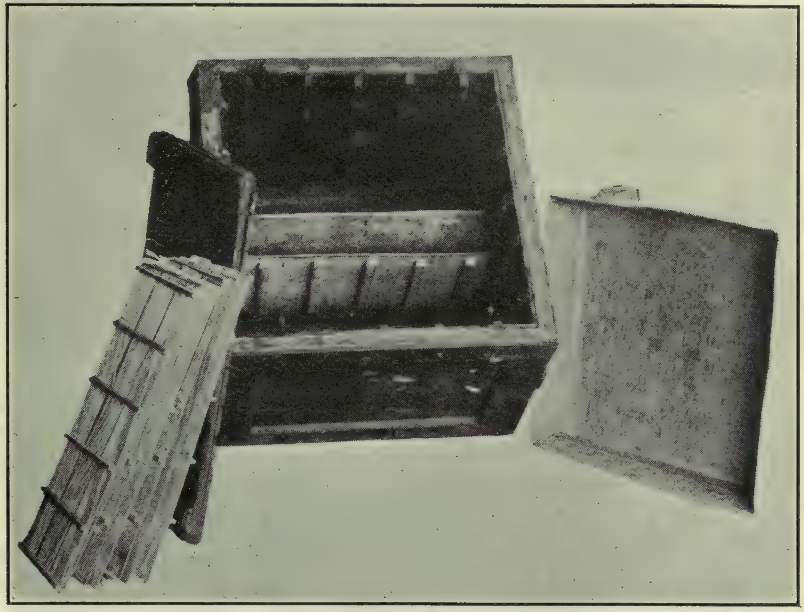
FIGURE 22.—A 24-pint display crate used in Louisiana.



BAE 23848

FIGURE 23.—A 36-oblong-pint berry crate used in Florida.

With the development of refrigerated trucks the pony refrigerator, formerly used in the shipment of early strawberries from Florida, has been practically discarded. This was a heavy case, usually holding eighty 1-quart boxes or 150 oblong pints (fig. 24). The layers of boxes were separated by dividers of the type used in the ordinary crates. Metal trays were placed in the center or in the top of the box, or both, to hold a supply of ice. Airtight covers were clamped on after the berries and ice had been packed in. These pony refrigerators were well adapted to long-distance express shipments when it was not possible to load full cars and when prices were high. Now this function is served as well or better by refrigerated motortrucks, and this does away with the necessity for returning the empty "reefers."



BAE 11285

FIGURE 24.—Pony refrigerator, formerly extensively used for early shipments of strawberries from Florida.

On the Pacific coast only half-pint and pint berry cups are used. These are of three principal types—metal-rim, paper, and Hallock. The first two are used in California. The Hallock is used in Oregon and Washington. The half-pint cups are used mainly for shipping raspberries, and the pint size for strawberries, Loganberries, blackberries, and similar sorts. The 24-pint crate is the most popular size for Hallock cups, and is made in a number of different styles.

Table 2 gives the dimensions of typical Pacific coast berry crates.

TABLE 2.—*Typical Pacific coast berry crates*

Capacity and type	Inside dimensions (inches)	Length of slat
		Inches
12-pint Hallock	2½ by 13⅝ by 18⅛	19¾
12-pint San Jose	$2\frac{11}{16}$ by 13½ by 18	19½
12-pint Imperial Valley	3⅞ by 13½ by 18	19
24-pint shallow Hallock	5⅝ by 16½ by 22¾	24½
24-pint deep Hallock	$5\frac{15}{16}$ by 13¾ by 19¼	19¾

In the Middle West, crates for Hallock cups are usually made in 24-pint and 16-quart sizes, typical dimensions being 6 by 10½ by $20\frac{11}{16}$ inches, inside, for the 24-pint crate, and 7½ by 10½ by $20\frac{11}{16}$ inches for the 16-quart size. Leslie cups are packed 24 to the crate. The typical dimensions are given in table 3.

TABLE 3.—*Typical Leslie-style berry crates*

Capacity	Inside dimensions (inches)	Length of slat
		Inches
24 half pints	4 by 13¾ by $20\frac{11}{16}$	22
24 pints	5½ by 13¾ by $20\frac{11}{16}$	22
24 quarts	7¾ by 15½ by $20\frac{11}{16}$	22

BRUSSELS SPROUTS

Brussels sprouts are shipped from California in drums and half drums (fig. 10) and in the artichoke box (9¾ by 11 by 20⅝ inches, inside). Long Island and other parts of the East use pint and quart berry boxes and crates.

CABBAGE [5]

Late cabbage is largely shipped in bulk or in sacks although some deliveries are made in barrels, hampers, crates, and baskets. In the early-season sections practically all cabbage is packaged, the use of crates and open-mesh sacks predominating. When bulk shipments are made from these sections the load is usually ventilated by means of an A-shaped slatted ventilator running lengthwise of the car.

In the past a large number of different sizes and shapes of crates have been used for cabbage and not infrequently cabbage that was not shipped in bulk has been packed in the most convenient type of container regardless of size. The diversity in cabbage crates was increased by the shippers' attempt to pack a certain weight of cabbage in a crate, the 100-pound basis being popular. As the weight varies widely according to the looseness or compactness of the heads this custom resulted in a great number of sizes. But the large cumbersome barrel size and 100-pound crates are now rarely found except for field or local use. Containers for cabbage have followed the trend during recent years towards smaller packages.

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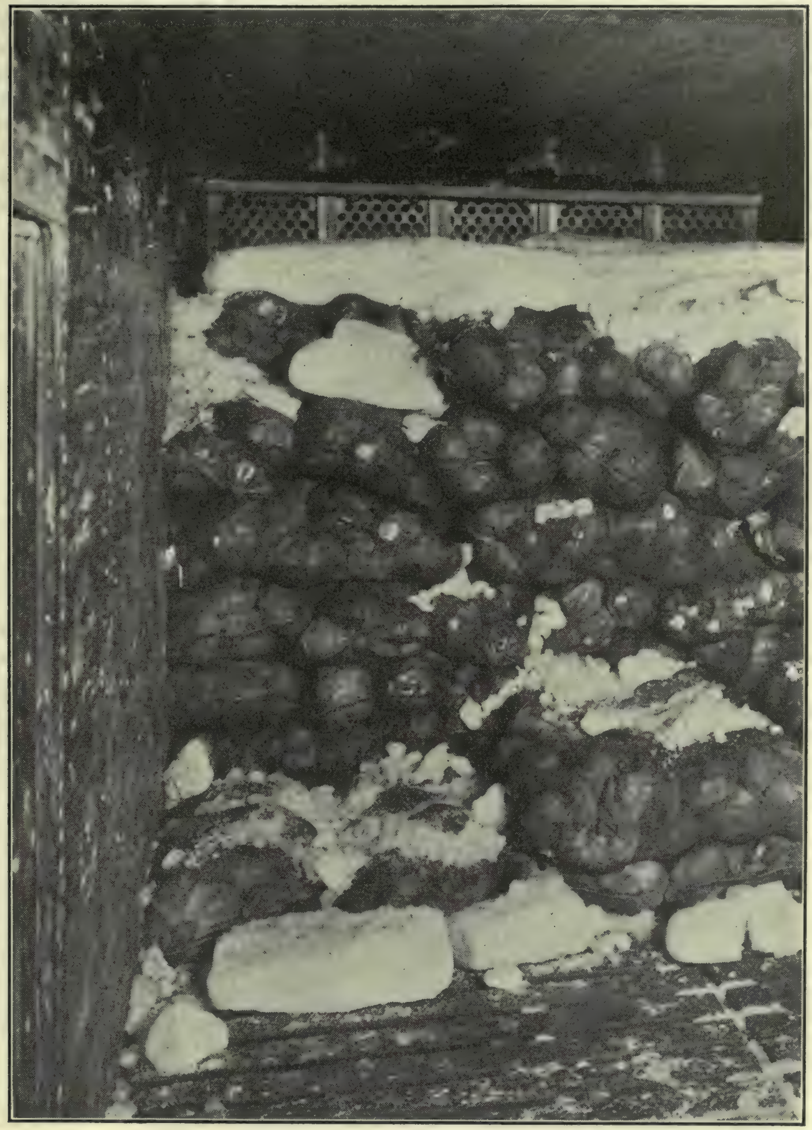
[5] The preparation of cabbage for market is discussed in Farmers' Bulletin 1423, Preparation of Cabbage for Market.

A very considerable part of the early cabbage crop is now shipped in 50- and 100-pound open-mesh sacks (fig. 25). In California, Texas, Mississippi, Louisiana, and some other early sections, the crates most commonly used are the so-called Los Angeles or western crate and the half crate. Typical specifications for the larger crate are 13 by 18 by 21⅝ inches, inside, and for the half crate, 9 by 13 by 21⅝ inches, inside. (See figs. 41 and 42.) Besides these crates in which



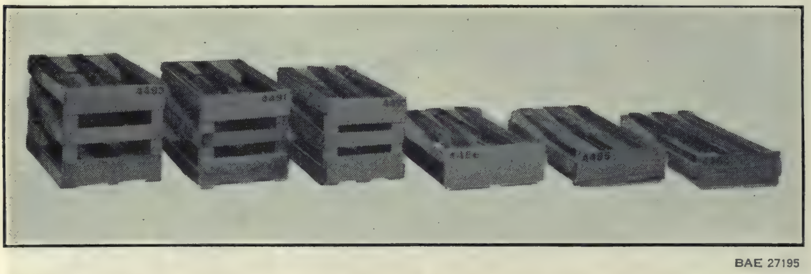
BAE 33787

FIGURE 25.—Texas cabbage in 50-pound open-mesh bags, showing method of loading with power-blown pulverized ice.

approximately 90 to 95 and 45 to 50 pounds of cabbage are packed, respectively, crates of similar capacity but different dimensions are used in Tennessee, Virginia, Florida, and elsewhere. The measurements of some of these crates are as follows: 12 by 16 by 22, 12 by 18 by 16, and 12 by 18 by 22 inches. Cabbage is shipped from Florida, South Carolina, and Virginia in 1½ bushel hampers.

CANTALOUPS

Over three-fourths of the carload shipments of cantaloups (in some years 85 percent) originate in Arizona, California, and Colorado. The crates (fig. 26) used in these States are designed to hold certain standardized packs of cantaloups, and their use has spread as far east as the Mississippi Valley. The same crates are used for Honey Ball melons. The sizes generally used in the West are provided for by law in Arizona, California, and Colorado except as noted in table 4. The standard packs shown are those prescribed in the Arizona law, and differ but slightly from those prescribed in the California law.



BAE 27195

FIGURE 26.—Western cantaloup crates. From left to right: Jumbo, standard, pony, jumbo flat, standard flat, and pony flat.

The standard, pony, and jumbo sizes are firmly established, but occasional variations are found in flat crates. The flats are used extensively in Colorado, and apparently their use is on the increase. As the melons are only one layer deep in this crate, they are easily inspected, and it is a convenient package for retailers to handle. The pony crates have their greatest use at the beginning and at the end of the season, when the melons are small.

TABLE 4.—*Standard western cantaloup crates*

Type of crate	Inside dimensions [1] (inches)	Standard packs of melons
		Number
Pony flat	4 by 12 by 22⅛	15, 18.
Standard flat [2]	4½ by 13 by 22⅛	9, 12, 15.
California Standard flat [3]	4½ by 13½ by 22⅛	9, 12, 15.
Jumbo flat	5 by 14½ by 22⅛	8, 9, 10, 11, 12.
Pony crate [3]	11 by 11 by 22⅛	45, 54.
Standard crate	12 by 12 by 22⅛	27, 36, 45.
Jumbo crate	13 by 13 by 22⅛	27, 36, 45.

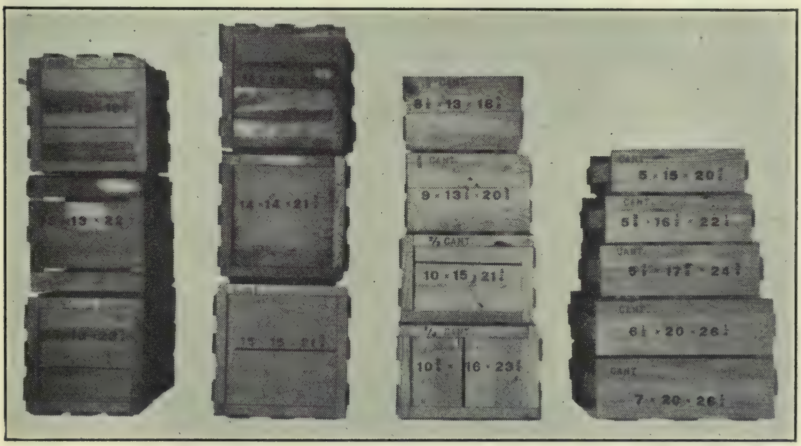
[1] Outside length of slat for all sizes, 23½ inches.
[2] Not standard in California.
[3] Not standard in Colorado.

Although the eastern crates are often known by the same names as those used in the West, they are often of different construction and dimensions. The paneled head is often used. In the southeastern section the standard cantaloup crate measures 12 by 12 by 22 inches, inside, with an outside length of 24 inches. This crate, therefore, is one-half inch longer, over all, than the western crate, and one-eighth inch shorter inside, the difference being due to the use of the paneled head.

In Maryland and Delaware few pony crates are used. Crates with 12- by 12-inch heads are known as standard, and those with 13- by 13-, 14- by 14-inch, and larger heads are known as jumbos; but in all of them the length of slats ranges from 22 to 26 inches. The flats used in this section are somewhat deeper and wider than the western type and vary in length from 22 to 28 inches. Typical heads measure 5 by 15, 5½ by 16½, and 6 by 18 inches.

In recent years a new type of double flat, or two-thirds crate, has become popular in this section and in North Carolina. One manufacturer reports four sizes of heads as being most important—8⅝ by 13, 9¼ by 14, 10 by 15, and 10⅝ by 16 inches, and slats from 22 to 28 inches long are used. The two-thirds crate used in North Carolina measures 8 by 12 by 22 inches, inside.

Possible combinations of these various sizes of heads and slats are almost incalculable, as are the different sizes of crates actually used in any one season. One of the reasons given for the multiplicity of sizes is that many varieties of melons are grown; but the principal reason is the attempt by growers to pack always the same number of melons to the crate. As the melons are likely to vary considerably in size this attempt to maintain a fixed count per crate has resulted in the practice of building crates to fit the pack instead of varying the pack to fit a few standard sizes of crates, as is done in the West. The latter method is believed to be the more advantageous not only from the standpoint of economical manufacturing and handling, but also in providing a more definite basis for buying and selling, since there can then be no uncertainty as to exactly what is meant by such trade terms as "pony 54," "standard 45," or "jumbo 36" (fig. 27).



BAE 30166

FIGURE 27.—Maryland cantaloup crates—full-size crates, two-thirds crates, and flats. Other sizes of heads and slats of varying lengths are used.

Much the same variation in crates which exists in Maryland is found in Michigan, except that in the latter State a great many pony crates with 9- by 9-, 10- by 10-, 11- by 11-inch heads are used. Only a few of the larger square-end crates are used. The flats have heads measuring 4½ by 14, 5 by 14, and 5 by 15 inches, and the slats on both styles of these crates vary in length from 18 to 24 inches. Here again the variation in sizes is due to an attempt to make the crate fit the pack. A considerable portion of the cantaloups grown in Michigan and Indiana, especially the smaller sizes, are shipped in bushel baskets and in 12-quart Climax baskets, which readily accommodate irregular sizes.

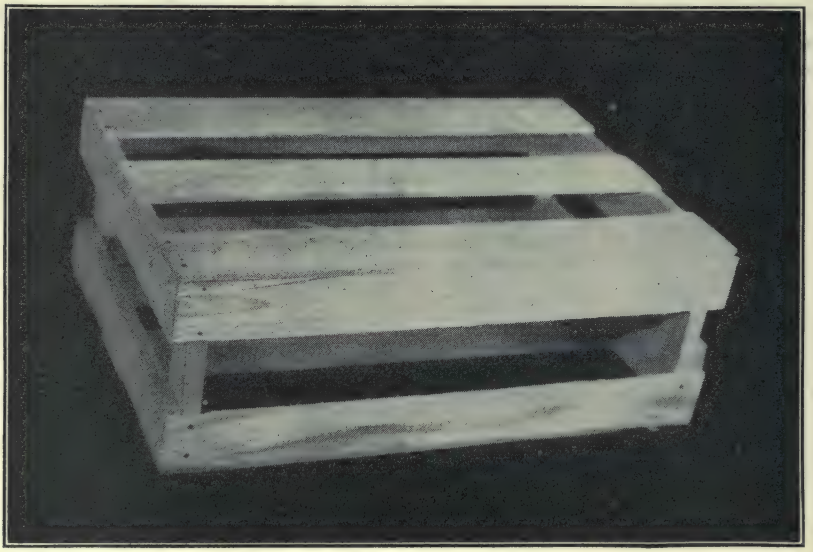
MISCELLANEOUS MELONS

Honey Dew melons are packed for the most part in pony, standard, and jumbo flats. The standard and jumbo are the sizes principally used. The inside measurements of these crates as fixed by law in Arizona, California, and Colorado are as follows: Pony, 5 by 14½ by 22⅛ inches; standard, 6½ by 16¼ by 22⅛ inches; and jumbo, 7½ or 7¾ by 16¼ by 22⅛ inches. The outside length of slat for all sizes is 23½ inches.

Crates known in some markets as "trunks" are sometimes used. One, with heads measuring 8¾ by 16 inches, is commonly used for Casaba melons. For Persian melons one manufacturer's tariff lists four crates: 6¾ by 12 inches, 7¾ by 14 inches, 9¾ by 16 inches, and 11¾ by 18 inches. The length is uniformly 22⅛ inches, inside.

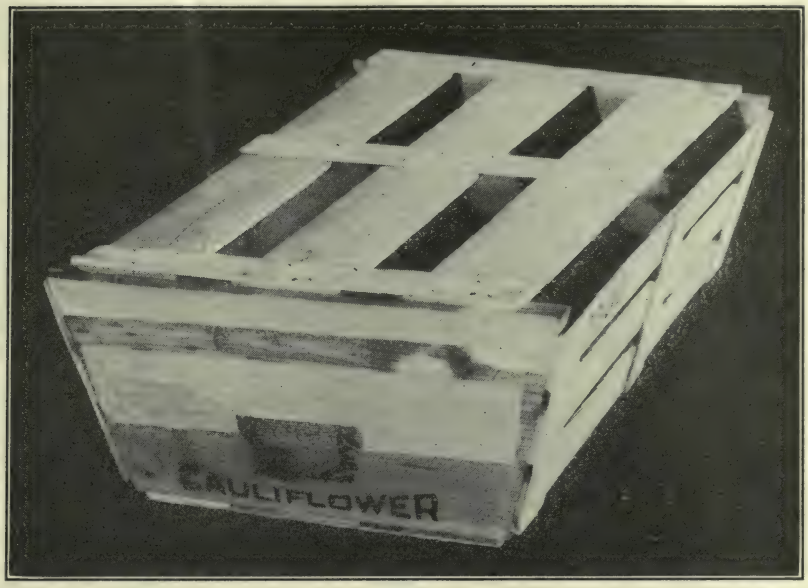
CAULIFLOWER

Cauliflower, because of the nature of the commodity, is generally packed in crates (figs. 28 to 30, inclusive). The California standard



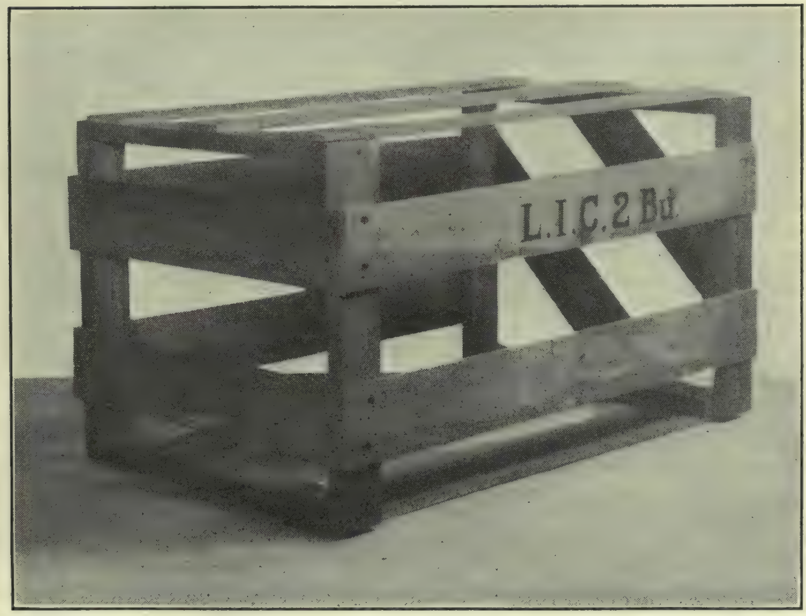
BAE 9578

FIGURE 28.—Cauliflower crate, western style.


CAULIFLOWER

BAE 11040

FIGURE 29.—New York cradle crate for cauliflower.



BAE 2430

FIGURE 30.—Long Island cauliflower crate.

pony crate (fig. 28) established by law in 1933, measures 8½ by 18 by 21⅝ inches, inside, and this crate is used also in Arizona and Colorado. A crate having the same width and depth but 23⅛ inches long is also used, the outside length, 24½ inches, being the same in both. Two crates are prescribed in State regulations in Oregon. One measures 8½ by 18 by 22⅜ inches, inside, with an outside length of slat of 24½ inches. The dimensions of the other, known as the jumbo crate, are 8 to 8¾ inches deep, and 17½ inches wide, inside, with slats from 24 to 24½ inches long. The crate reported from Washington measures 8½ by 17 by 22 to 22½ inches, inside.

For trimmed cauliflower some California shippers use appreciably smaller crates, one of which measures 6⅝ by 15⅝ by 19⅜ inches, inside.

One of the most common and satisfactory of the eastern cauliflower containers is the New York cradle crate (fig. 29), which is used principally in the western part of the State. It affords plenty of ventilation in transit because of its shape, and is an attractive sale package, as the cauliflower heads can be seen from either the top or the bottom. Its inside dimensions are, depth, 8 inches; width, 13½ inches at bottom, 18 inches at top; length, 22⅜ inches. A similar crate used in Tennessee is 9¾ inches deep, 16 inches at top, 10 inches at the bottom, and 29 inches long, inside.

An entirely different crate (fig. 30) is used in the Long Island cauliflower section. Although this crate has been in use for many years, some manufacturers report the depth and width as 13 by 15 inches, whereas others report 13½ by 15½ inches, the length of slat being uniformly 23 inches. This crate does not seem to have commended itself to any growers other than those on Long Island. The Catskill Mountain section uses several different types of crates and has not as yet settled on any one as standard.

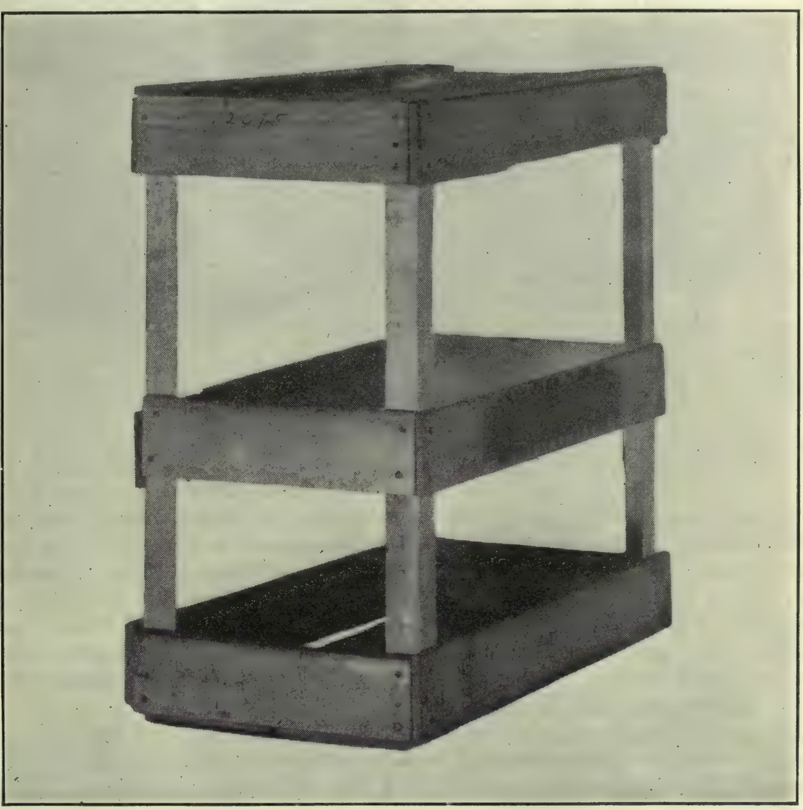
In Michigan a crate that measures 8 by 19½ by 27⅛ inches, inside, is used, from 12 to 16 heads being packed in it.

CELERY

Celery must necessarily be shipped in crates and boxes designed especially for it. It may be packed in the rough, or it may be trimmed, washed, and bunched. When shipped from the producing sections in the rough, it is trimmed, washed, and bunched by city distributors. Carload shipments of celery are made from 14 States, but the most important shipping sections are in Florida, California, New York, Michigan, and Oregon, which shipped 17,707 of the 17,998 carloads that moved in 1935. For practical purposes, therefore, consideration need be given only to the crates used in these five States.

For western celery the old California crate, sometimes referred to as the full-size or standard crate, measuring 20 to 24 inches, depth, 24 inches, width, and 20⅝ inches, length, inside, has been almost entirely displaced by the half crate in recent years. The predominant style of this half crate (fig. 31), is constructed with corner posts, rails, and slats as in the large crate, and measures 11 by 20⅝ inches, width and length, with depths usually 22 or 24 inches, inside.

The Florida crate (fig. 32), sometimes called the one-half crate or 10-inch crate, is used for the shipment of all full-length, untrimmed Florida celery. The dimensions are 20 inches, depth; 10 inches, width; and 22 inches, length, inside. No variation is made in depth to adjust it to differences in the length of the celery. Florida shippers make a practice of sizing their rough celery, and pack 3, 4, 6, 8, or 10 dozen stalks to the crate.

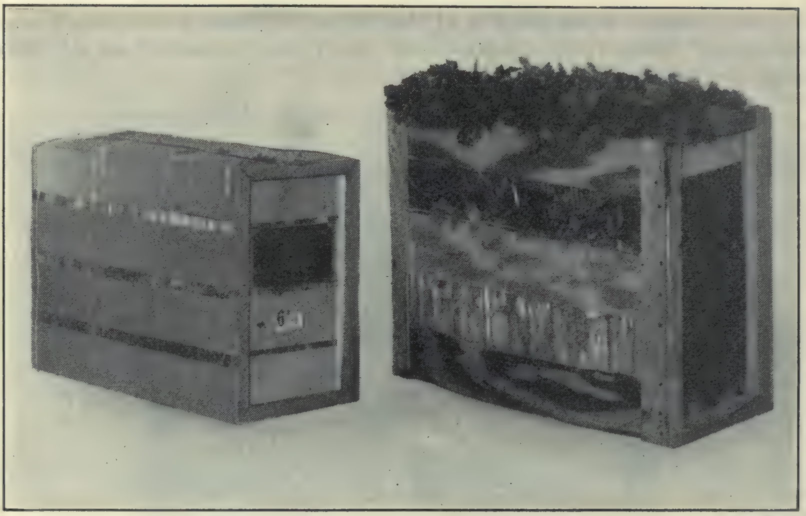


BAE 23879

FIGURE 31.—Western half crate for celery.

Before 1935 practically all Florida celery was packed with full tops in the standard crate. Since that time an increasing part of the crop is trimmed to 16 inches over-all length and packed with tops and bottoms reversed in alternate layers. The crate used is the same as the standard crate in width and length but is only 16 inches deep (fig. 32). As the quantity of edible celery is practically the same in both crates, substantial economies are claimed for the smaller crate in package and transportation costs, and it eliminates much of the trimming operation at destination.

The trimming is usually done in the field. A special field crate, open at the top and with one side completely removed except for a 2-inch riser, is used. The stalks are butted tight against the closed side and pressed down compactly with a pressboard. The riser at the bottom and the pressboard at the top furnish cutting edges against which the tops of the celery are lopped off with a large knife or a saw. The celery is then graded and washed in the usual way preparatory to packing.



BAE 33789

FIGURE 32.—Florida celery crates: Left, celery trimmed to uniform length of 16 inches; right, celery with full tops in standard Florida crate.

The crate used for rough celery in Michigan, and in New York and New Jersey, is generally called the two-thirds crate, and has been standardized by all three States. The inside dimensions are 22 inches, depth; 16 inches, width; and 20¾ inches, length, inside. In Michigan the length is specified as 21 inches, and the crate is used chiefly as a field or storage container. Smaller sizes of this crate variously designated "half crate," "one-third crate," etc., have been observed in New Jersey and New York.

A great number of sizes of crates have been and still are used for rough celery in other sections, but it is believed that the tendency is toward the adoption of some one of the half crates mentioned. The larger of two crates used in Colorado is about halfway between the California and the New York crate, measuring 20 by 21 by 22 inches, inside. The Colorado half crate is 12 by 21 by 22 inches, inside.

Michigan is the principal State using special containers for washed celery, and both boxes and crates are used. By agreement of growers and shippers, standard terminology and dimensions were adopted in 1936. One crate is known as the "hiball" and another as the "hyboy." The ends of the former measure 8 by 10 inches, and of the latter 12 by 18 inches. The inside length of the hiball is restricted to 18, 20, or 22 inches, but that of the hyboy varies from 6 to 30 inches by 2-inch steps. Celery packed in these crates is sold by the dozen bunches, and the variations in length are used to fit the crate to the number of dozens it is desired to pack.

The boxes are called flats and squares; the heads are, by agreement, 5 by 11½ and 8 by 8 inches, respectively. Five lengths of slats are permitted in both: 14, 16, 18, 20, and 22 for the flats, and 10,12, 14, 16, and 18 for the squares. Celery in these boxes is usually sold by the box. The diversity of sizes in these crates and boxes is due largely to the demands of wholesale receivers for different quantities and different sizes of celery from time to time throughout the season.

Special crates for washed celery are not used to any extent in the other principal producing sections. New York uses the two-thirds or New York crate and the 10-inch or Florida crate. Florida and California ship washed celery in the same kinds of crates as used for rough stock. Colorado uses no crates for its washed celery but ships it tied in bunches in carloads of mixed vegetables.

CHERRIES

The use of boxes for shipping cherries is confined chiefly to the Pacific Coast and Rocky Mountain States. In 1935, 1,480 of the 1,529 carload shipments originated in California, Washington, Oregon, and Idaho. There is much confusion as to the sizes of cherry boxes, and the standards established by several States throw little light on the situation, because of their multiplicity and because in so many instances boxes that are not standard are used (table 5).

The wish of certain shippers to use distinctive packages, and attempts to pack a certain number of pounds to a box, have undoubtedly been responsible for some of the variations in the specifications used. Again, cherries are said to vary in weight from one season to another, and from the first of the harvest to the last, depending upon the sugar content. Sweet cherries have a relatively high value per pound, and the shipper who pays cash for loose fruit must necessarily pack close to the weight marked on the container or lose much of his profit through overweight. But it is doubtful whether so many different types of containers are necessary.

TABLE 5.—*Cherry box standards established by State law or regulation*

Common name	Inside dimensions (Inches)	Standardized by
Eastern flat	2¼ by 9 by 18 to 18⅛ [1]	California, Oregon, Washington, Idaho.
Tozzi lug	2⅞ by 11 by 16⅛ [1]	California.
Campbell lug	3¾ by 11½ by 14⅛ [2]	Do.
Do	4 by 11 by 14 [3]	Oregon.
Calex lug	3¾ by 13½ by 16⅛ [1]	California.
Lambert lug	3 by 9¾ by 18⅛ [1]	Do.
15-pound box	3 by 11 by 18	Idaho.
Peach box	4 by 11½ by 18	California.
California box	4 by 13½ by 16⅛ [1]	Do.
Los Angeles lug	5¾ by 13½ by 16⅛	California, Oregon.
20-pound box	4½ by 9 by 18 [1]	Washington, Idaho.
Northwest fancy box	4⅛ or 4¼ by 8⅝ by 17¼	Oregon.

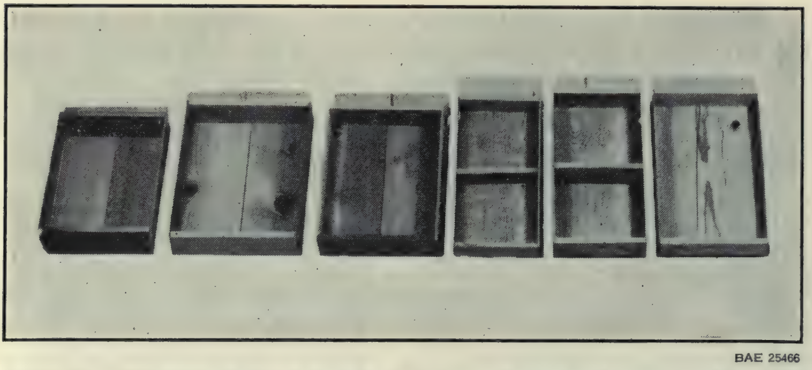
[1] Specifically for cherries.

[2] ⅜-inch cleat usually used to increase depth.

[3] Oregon regulations permit ¼-inch variation in depth and ½-inch variation in width but require 15 pounds net contents.

In addition to the prescribed standard boxes, all of which are probably used to some extent, many others have been noted. Among them are the Brookside lug and the Guiffre lug (variants of the Calex lug), and the Clement and Martino lugs which are shallow variants of the peach box (fig. 33). But it appears that, for the large bulk of western cherry shipments, six packages are particularly important.

The eastern flat, holding about 8 pounds of fruit, is used rather extensively in California for early shipments. Few appear to be used elsewhere. The Lambert lug holding about 12 pounds is also popular in California and is used in Washington. The Los Angeles lug, hold-



BAE 25466

FIGURE 33.—Western cherry boxes vary in size, shape, and construction. From left to right: Campbell lug, Brookside lug, Guiffre lug, eastern flat, Lambert lug, and Clement lug.

ing 27 pounds with cleats, and 24 pounds without cleats, is used chiefly for local shipments in California. In Washington, this package, usually without cleats, is frequently packed with 20 pounds net of cherries. Used in the same way in Oregon, it is second in popularity there only to the northwest fancy box in which the cherries are row-packed throughout. In recent years the Campbell and Calex lugs, each holding about 15 pounds of cherries, have become predominant in western shipments. The former is usually single or double-faced and filled; the latter is frequently used for loose cherries. Unfortunately as used by different shippers it varies considerably in width and length as well as in depth. A crate that holds twelve 1-pint boxes is used for cherries in the Santa Clara Valley of California.

In the Eastern States, notably in Michigan and Wisconsin, cherries are packed either in the 16-quart American or Hallock berry crate. In New York, New Jersey, Maryland, and Pennsylvania, the 32-quart American crate is used, and in these States some cherries are marketed in 4- and 12-quart Climax baskets.

CITRUS FRUIT[6]

Formerly only two orange boxes were in common use—the California box that holds approximately 1½ bushels and the Florida box that holds 1⅗ bushels (figs. 34 and 35). The former has been standardized by law in California and Arizona, and the latter in Florida and Texas.

The essential difference in the two boxes is in the size of the heads, the California heads measuring 11½ by 11½ inches and the Florida heads, 12 by 12 inches. Whatever the original cause of this slight difference, it should be borne in mind that Florida uses the panel head, whereas California uses a solid head, which, if made of one piece, can hardly be cut wider than 11½ inches from the standard 12-inch board.

From time to time there has been discussion as to the desirability of adopting one standard orange box, but the difference in the method

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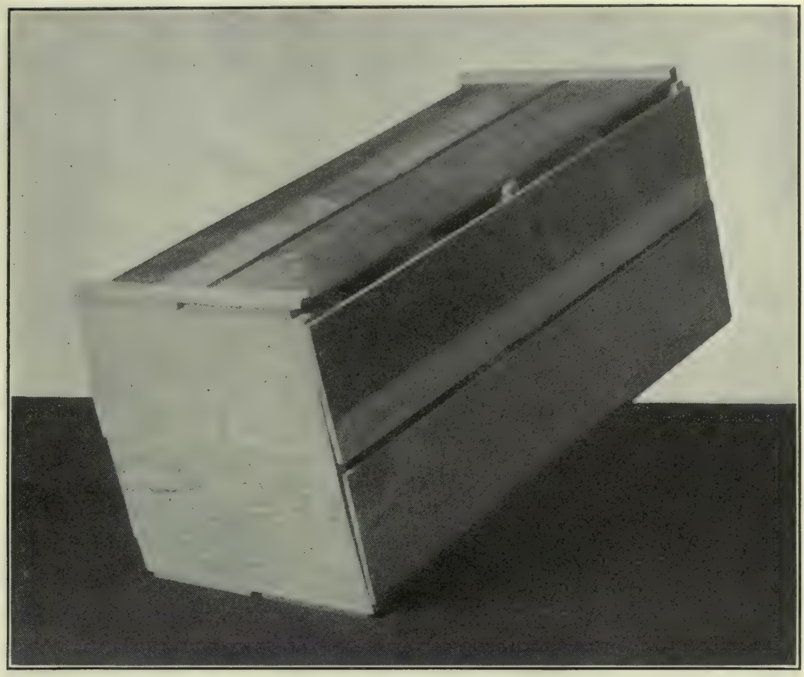
[6] The harvesting and handling of citrus fruits in the Gulf States is discussed in Farmers' Bulletin 1763, Harvesting and Handling Citrus Fruits in the Gulf States.



BAE 4580

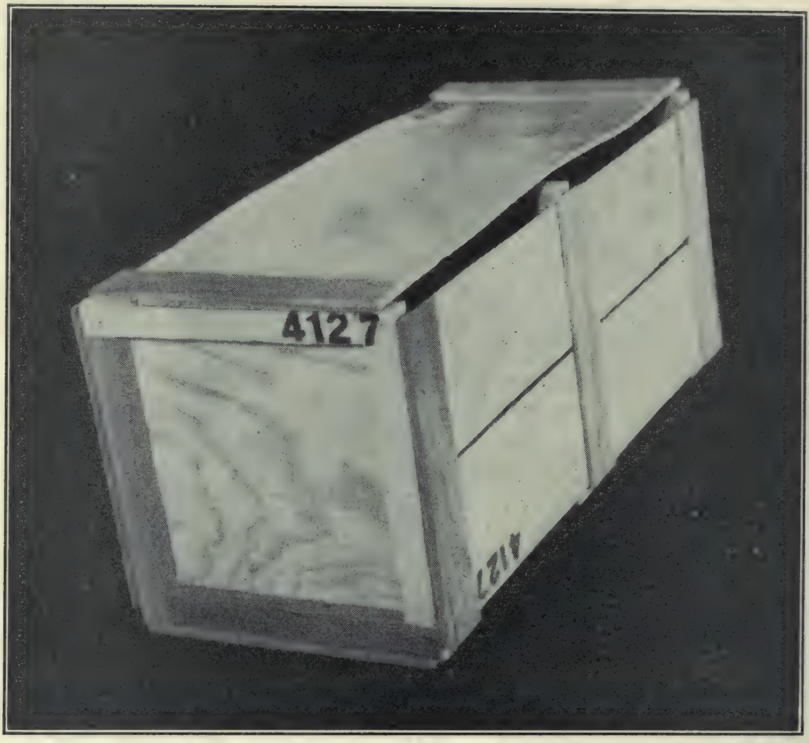
Figure 34.—Standard California and Arizona orange box.

of construction and the fact that the packs now in use have been worked out on the basis of the present measurements have prevented any attempt to bring about uniformity. Furthermore, citrus fruit as packed in crates is sold by numerical count and not by measure.

A half size of the Florida orange box, called a strap, has been standardized by law in Texas, and by agreement in Florida. The full-sized box is used for grapefruit. California and Arizona have standardized a half size of its orange box and have adopted standard and jumbo lemon boxes and half sizes of each. Table 6 gives the dimension specifications for the various citrus boxes standardized by State law.

Table 6.—*Standard citrus fruit boxes*

Type of box	Net inside dimensions (inches)	Outside length of slat	Capacity
		Inches	*Cubic inches*
Florida and Texas orange	12 by 12 by 24	27	3,456
Florida ½ orange	6 by 12 by 24	27	1,728
California and Arizona orange	11½ by 11½ by 24	26	3,174
California ½ orange	5¾ by 11½ by 24	26	1,587
California standard lemon	10 by 13 by 25	27	3,250
California ½ standard lemon	5 by 13 by 25	27	1,625
California jumbo lemon	11⅛ by 13½ by 25	27	3,755
California ½ jumbo lemon	5⁹⁄₁₆ by 13½ by 25	27	1,877



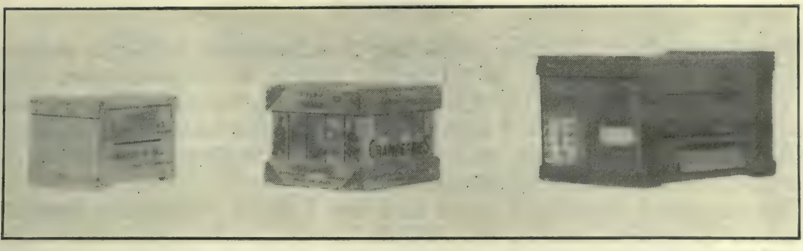
BAE 13023

FIGURE 35.—Standard Florida and Texas orange and grapefruit box.

In recent years increasing quantities of oranges and grapefruit from both Texas and Florida have been marketed in tub baskets, open-mesh sacks, and wire-bound crates. Consumer-size sacks of 5-, 8-, and 10-pound capacity have been used to some extent, but the larger sizes are by far the most popular. Texas regulations authorize the use of ⅕-, ⅖-, ⅘-, 1-, and 1⅗-bushel sacks. The wire-bound crates used for citrus fruit are designed to be packed flat without any bulge and are made chiefly in three sizes—⅘, 1⅗, and 2 bushels. During the 1937–38 season more than half the shipments from Florida and Texas were made in the 2-bushel size package, but administrative restrictions subsequently imposed by both States may curtail its future use. Only a few shipments in this container were reported from California. In Florida some of the ⅘-bushel and 1-bushel, two-compartment crates similar in design to the standard box are used. The Florida half box is a popular package for tangerines, but tub baskets are also used. The half strap is used largely for satsuma oranges from Alabama.

CRANBERRIES

Containers for cranberries are based almost entirely on the standard cranberry barrel established by Congress in 1915. This law fixes such dimensions as to produce a barrel having a content of 5,826 cubic inches. This barrel, designed to hold 100 pounds of cranberries,



BAE 27805

FIGURE 36.—A good example of standardization—One-eighth, one-fourth, and one-half cranberry-barrel boxes.

is no longer used, nor are the subdivisions known as the one-third, one-half, and three-fourths barrel. Instead boxes equivalent to one-eighth, one-fourth, and one-half cranberry barrels are used almost exclusively and are designated one-eighth, one-fourth, and one-half cranberry-barrel boxes, respectively (fig. 36).

Although the style is obsolete, the standard cranberry barrel has been adopted by law in the District of Columbia, Illinois, Massachusetts, Michigan, New Jersey, Oregon, Virginia, Washington, and Wisconsin. Six States—Illinois, Massachusetts, New Jersey, Oregon, Washington, and Wisconsin—have provided by law for standard cranberry boxes. The box adopted by Massachusetts and New Jersey has inside dimensions of 7½ by 12 by 22 inches, with a capacity of 1,980 cubic inches, 38 cubic inches in excess of a one-third cranberry barrel. Oregon provides for the use of a one-third cranberry-barrel box; Washington specifies that the cranberry-barrel box shall contain 1,942 cubic inches or one-third of a barrel; Wisconsin and Illinois specify a 1-bushel box as standard for cranberries.

The boxes actually used for shipping cranberries (one-eighth, one-fourth, and one-half cranberry-barrel boxes) have not been adopted as standard by any State but have come into use as a matter of trade practice on the part of organizations that handle and ship cranberries and are usually legibly marked as to size in terms of the cranberry barrel.

The one-fourth cranberry barrel box is most widely used and is made in two styles. One has inside dimensions of 9¼ by 10½ by 15 inches; the other measures 9½ by 11 by $13\frac{15}{16}$ inches, inside, and contain 1,456.9 and 1,456.5 cubic inches, respectively, or one-fourth of a cranberry barrel. One of the most commonly used one-eighth cranberry-barrel boxes measures $7\frac{11}{32}$ by 8⅜ by 11⅞ inches, inside, and the dimensions of a popular one-half cranberry-barrel box are $10\frac{13}{32}$ by 14 by 20 inches, inside, giving them capacities of 730.4 and 2,913.75 cubic inches, respectively.

Some confusion may exist regarding the quantity of cranberries packed in a box because of differences in methods of packing. Growers who pack the box full and then force the bottom in place put approximately 50 pounds of cranberries in a ½-barrel box. When pressure packing is not employed the box may not contain so great a weight of cranberries.

GREEN CORN

Green corn from Florida and other Southeastern States is shipped in bushel crates 12 by 12 by 15 inches, inside, in a special corn crate 12 by 12 by 22 inches, in various types of 1½-bushel crates, one of which is 12 by 12 by 22½ inches, inside, in the half-barrel cabbage crate, in the celery crate, and in the wire-bound citrus-fruit crates. The pack varies from 4 to 12 dozen ears.

The standard cantaloup crate and the Florida corn crate, both 12 by 12 by 22 inches, inside, are used in North Carolina and some other parts of the South. The bushel basket and box and some open-mesh bags are used in Texas and Louisiana. Alabama ships mostly in 1⅓-bushel crates or bags (fig. 37).

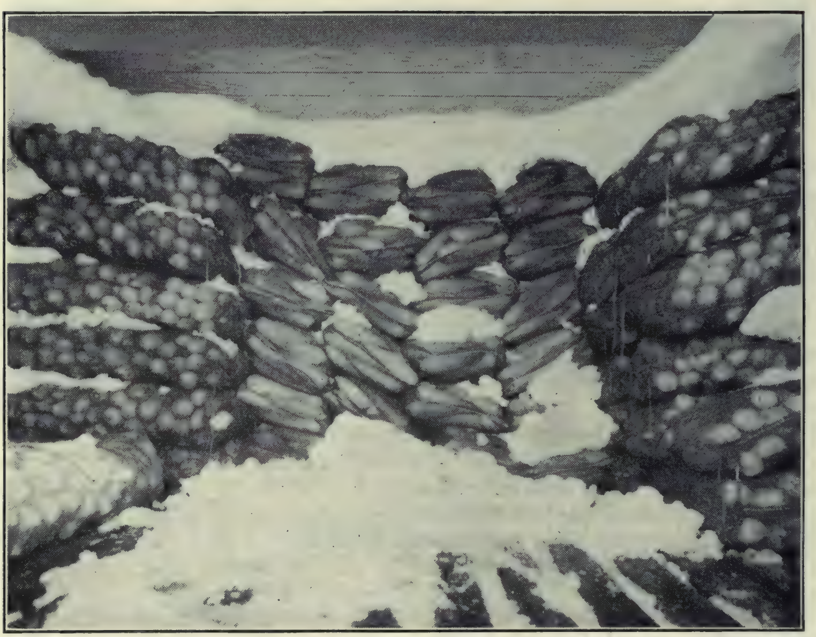

BAE 33788

FIGURE 37.—Car partly loaded with Texas green corn in 1-bushel open-mesh bags.

A crate used to some extent in the Southwest is 12 by 12 by 20¾ inches, inside. On the Pacific coast a 12-dozen two-compartment crate measuring 11 by 13 by 29 inches, inside, is used.

CUCUMBERS

Florida is by far the largest shipper of cucumbers. They are packed in bushel hampers and tub baskets and in the 12 by 12 by 15-inch bushel crate. A crate measuring 9 by 13 by 22 inches, inside, and the 1½-bushel crate, measuring 12 by 12 by 22½ inches, inside, are also used. The bushel tub basket is popular in the Carolinas, Louisiana, and Texas. From Virginia north, bushel hampers and baskets are used to a great extent; 12-quart climax baskets and splint baskets are used in Illinois, Indiana, and Ohio and lug boxes in California.

FIGS

Fresh figs from California are shipped in shallow boxes in which fillers are placed to provide a cell for each fig. The number of cells used depends on the size of the figs to be packed. These boxes vary in depth from 1¾ to 2 inches, and are 11 inches wide by 16½ inches long. They hold approximately 5 pounds of figs. Shallow baskets having the same top dimensions as the 3-quart basket and packed four to the crate are sometimes used.

GRAPES

The types of containers used for shipping the American type of grapes, grown principally in the eastern part of the country,[7] differ from those used for the European type, grown mainly in California. For the American type of grape the principal container is the Climax basket, of which there are three sizes—the 2-, 4-, and 12-quart (see fig. 3). In recent years for fancy table grapes the 2-quart till basket, packed 8 or 12 to a carrier crate or carton, has become popular (fig. 38).

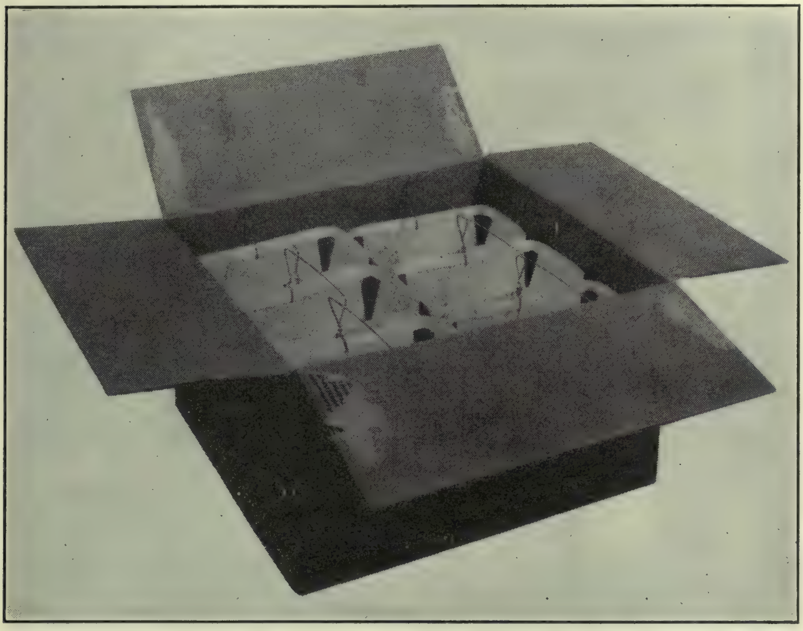

BAE 18369

FIGURE 38.—Twelve-basket carton for eastern grapes. Baskets are 2-quart oblong tills with wire overhandles.

The greater part of the vinifera (European) grape shipments from California is shipped in boxes, commonly referred to as lug boxes. Some grapes are shipped in 3-quart baskets enclosed in crates, and some in kegs and drums, the latter being used for grapes packed in sawdust, cork, or similar material. However, special lug boxes are being used increasingly for this type of pack.

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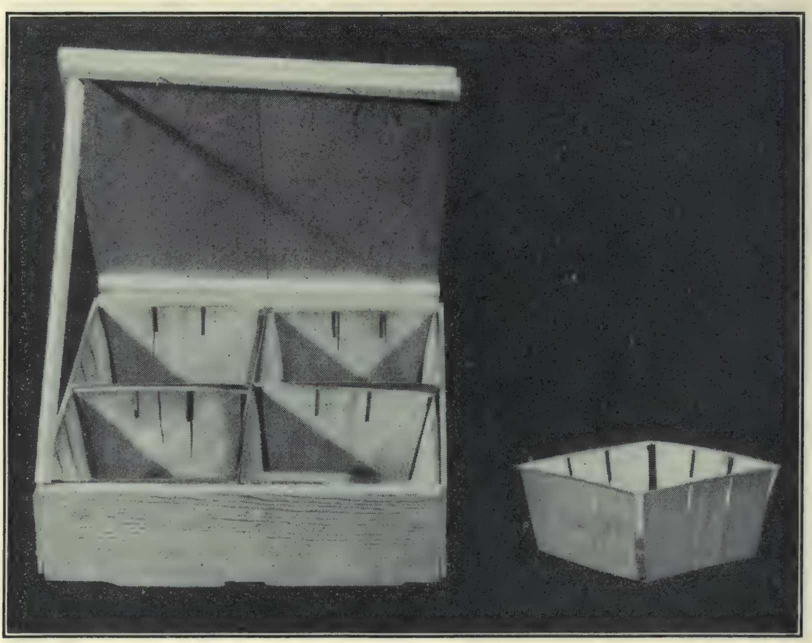
[7] The preparation of eastern grapes for market is discussed in Farmers' Bulletin 1558, Preparation of Eastern Grapes for Market.

Most shipments of vinifera grapes originate in California, and for many years there has been an attempt in California to bring about the standardization of grape containers, but the demands of shippers' organizations for variations in sizes have always more or less nullified the effort. The California Standardization Act as amended in 1937 provides for a number of permissive standard containers which if used may be marked "standard." These include the United States standard 4-quart Climax basket and the 3-quart till basket. For the sawdust packs there is a standard grape drum and a standard grape keg, each containing 2,642 cubic inches, and two lugs 7¾ and 11 inches, depth, by 13½ inches, width, by 16⅛ inches, length, inside. The practice of packing in sawdust is diminishing, and few drums are used.

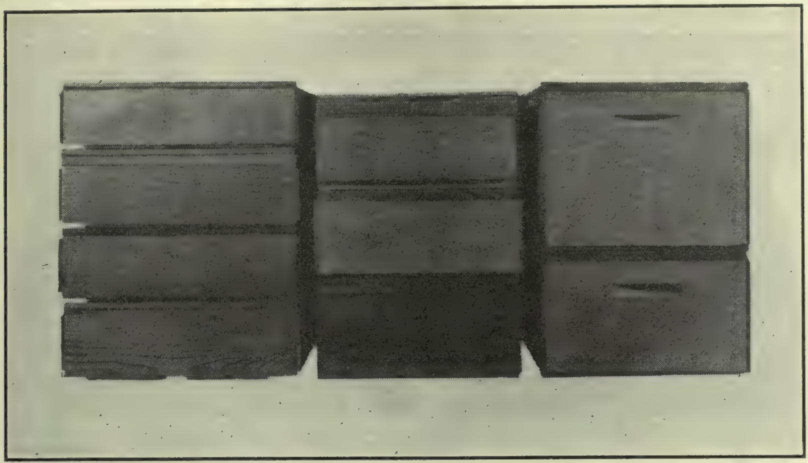


BAE 20528A

FIGURE 39.—Standard California four-basket crate. Baskets are of 3-quart capacity.

Approximately 20 percent of the sawdust pack is put up in kegs, approximately 32 pounds of grapes to the keg. Only the smaller of the two standard lugs is used. It holds 22 pounds net of grapes. Most sawdust-pack grapes are packed in a nonstandard lug measuring 7¾ by 14⅞ by 18⅝ inches inside and holding 32 to 34 pounds net of grapes. When four-basket crates are used the depth may be 4, 4¼, 4½, or 4¾ inches by 16 inches by 16⅛ inches inside (fig. 39).

Two sizes of grape lugs (fig. 40) are provided, 5³⁄₁₆ and 5¾ inches deep, the width and length being the same as the sawdust-pack lugs—13½ by 16⅛ inches. The State law requires an ¹¹⁄₁₆-inch cleat to be used with the 5³⁄₁₆-inch head. The second head may be used with or without an ¹¹⁄₁₆-inch cleat. The actual depth therefore is 5¾ inches in the first and either 5¾ or 6$\frac{7}{16}$ inches in the second. The so-called display lug is restricted in depth to 5¾ inches. The heads of this lug are usually made of two pieces, one 4½ and the other 1¼ inches wide. In one respect the various lugs and crates are uniformly standard; that is, the outside length is 17½ inches.



BAE 27200

FIGURE 40.—Standard California grape crates and lugs. Left: Crates for four 3-quart baskets may be 4, 4¼, 4½, or 4¾ inches deep. Center, reading from top: Display lug, 5$\frac{1}{16}$ and 5¾-inch lugs (the 5¾-inch or Los Angeles lug is a leading package for tomatoes). Right: Sawdust-pack lugs.

It will be seen that California provides for 11 different permissive standard containers for grapes; and this situation may be further complicated by the fact that others may be used if they are not marked "standard." One such nonstandard lug that is extensively used is the so-called No. 2 lug, 4¾ inches deep, which may be used with or without a cleat. Another is a tapered-end box that comes in several slightly varying specifications. When the cleat is used, it is obvious that the boxes can be packed level with the cleat, and that when they have reached the receiving market the cleat can be removed and the box appear full even though considerable settling may have occurred.

LETTUCE

Lettuce is marketed in a great many different styles and sizes of crates, boxes, and baskets, but most of the carload shipments originate in Arizona, California, Colorado, Idaho, New York, and Washington, where only crates are used. Obviously the crate is the most important of the packages.

The so-called Los Angeles, or western lettuce, crate is perhaps best known and most widely used. As originally standardized by California law it was 13 inches deep, 18 inches wide inside, with an outside length of 24½ inches and a minimum inside length of 21⅝ inches. This unusual provision was to allow two types of construction (fig. 41), the Los Angeles type being made with the end slats on the inside of the end posts and the Brawley type with the slats on the outside. Two crates are now provided, one 13 and the other 13¾ inches deep, the width and length inside being 17½ and 21⅝ inches, respectively. These crates are used for packing from 36 to 90 heads of lettuce. The law requires that each crate shall be conspicuously stamped with the exact number of heads contained.

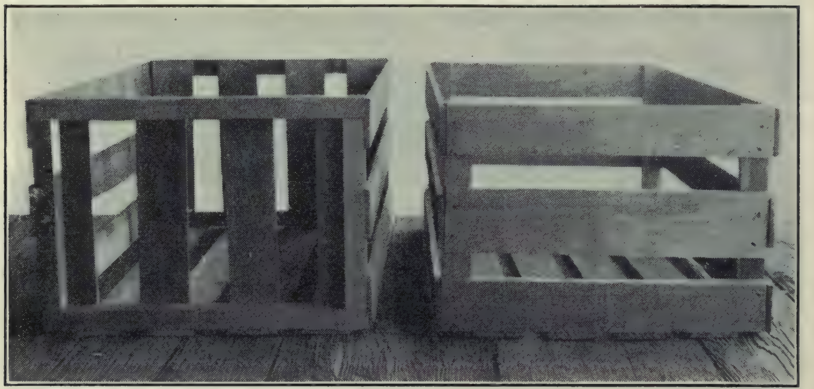

BAE 10757

Figure 41.—Western-type lettuce crate showing two styles of construction.

What was known as the Salt Lake crate was formerly used in California to some extent. It went out of use for a number of years but has recently been reintroduced. This crate, often referred to as the half crate, is practically one-half the size of the larger crate. As standardized by California law, this crate measures 9 to 9½ by 13 by 21⅝ inches inside (fig. 42).

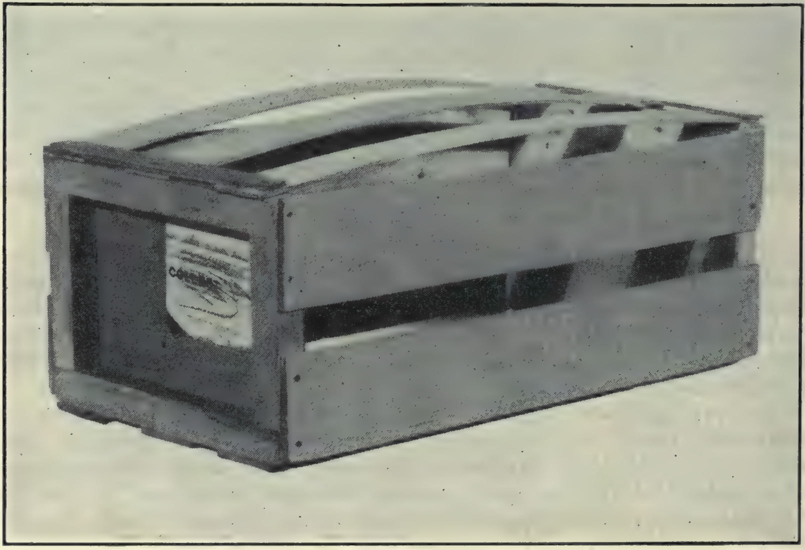
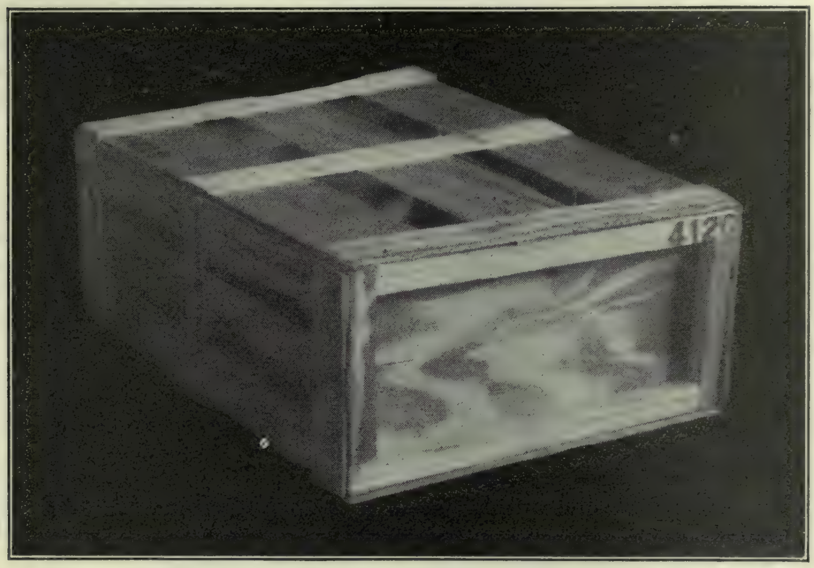

BAE 23855

Figure 42.—Half lettuce crate, western type.

The California-type crates are also used in Arizona, Colorado, Idaho, Oregon, and Washington, although minor variations are sometimes found in them. Arizona prescribes a crate 13 by 17 by 21⅛ inches. In Idaho a similar crate is used, with the length 22½ inches. In Washington, in some instances, crates with heads measuring 14 by 17 inches instead of 13 by 18 inches are used. The latter is prescribed in Oregon.

In New York three sizes of crates were formerly used, each designed to hold 24 heads of lettuce, but after considerable discussion the growers decided to discard all of them and adopt a new crate measuring 7½ by 16 by 19 inches inside (fig. 43). This crate has been made by law the standard crate of New York, and it is now generally used in the Atlantic Coast States and Florida.



BAE 13031

FIGURE 43.—Standard New York lettuce crate.

Although the bulk of the head lettuce is marketed in crates, much of the Florida crop moves in the 48-quart hamper, and in North Carolina the 40-quart hamper is used.

Leaf lettuce is marketed in a variety of containers, some gardeners using lug boxes and second-hand vegetable, sugar, and flour barrels. The growers of hothouse lettuce in northern Ohio use a square-cornered splint basket, holding 10 pounds of leaf lettuce. Smaller splint baskets, holding 3 pounds, are used by some growers. Some leaf lettuce is marketed in ¾-bushel and 1-bushel round stave baskets holding approximately 10 and 15 pounds, respectively.

MUSHROOMS

In the Kennett Square district of Pennsylvania a principal shipping container for mushrooms is the 4-quart Climax basket, holding approximately 3 pounds. A 4-quart square-cornered splint basket is sometimes used by growers around Cleveland, Ohio. Mushroom growers have sought a satisfactory wooden container, holding only 1 pound or less, the idea being to put this commodity on the market in a package that could be sold intact to the consumer. Paper cartons holding ½, 1, and 2 pounds are used, and in 1934 the Standard Container Act of 1916 was amended to provide a standard 1-pound Climax basket exclusively for mushrooms (fig. 2).

OKRA

As only a limited quantity of okra is raised, most of the shipments are made by express, and whatever package is most convenient at the time is used. The greater number of these shipments originate in the southeastern part of the country, where the common packages are the bushel hamper or basket and the 1-bushel crate.

ONIONS

The 1-bushel folding onion crate, long established by law in Texas and recognized throughout the United States as the standard onion crate, is no longer extensively used. The 50-pound sack has become the most popular container for onions and is used in practically every onion-growing section of the country (fig. 44). Some 25-pound sacks and some 10- and 5-pound sacks are also used.

Many Egyptian and Spanish onions are shipped to the United States. The former are packed in jute bags that hold about 112 pounds. Spanish onions are packed in cases, half cases, and crates, containing 125 to 130, 65, and 37 to 40 pounds, respectively. A common type of crate for Spanish onions measures 6⅜ by 18 by 18 inches outside and holds 50 onions—20 in one compartment and 30 in the other. Another crate measures 10½ by 14¾ by 39 inches outside and holds 150 onions.

PEACHES[8]

Boxes are commonly used for shipping western peaches. The western peach box has the same width and length as the pear and apple boxes (11½ by 18 inches inside), but there is considerable variation in depth. State standards include depths varying from 3½ to 6 inches in half- and quarter-inch intervals (fig. 45). The 4½-inch depth is perhaps the most popular, but the 4-, 4¼-, and 4¾-inch depths are also largely used for the standard packs, in which 32 to 96 carefully sized peaches are arranged in diagonal or offset rows, two layers deep. The 5-inch and deeper boxes, usually packed three layers deep, and the shallower boxes, sometimes packed with one layer, are rarely used.

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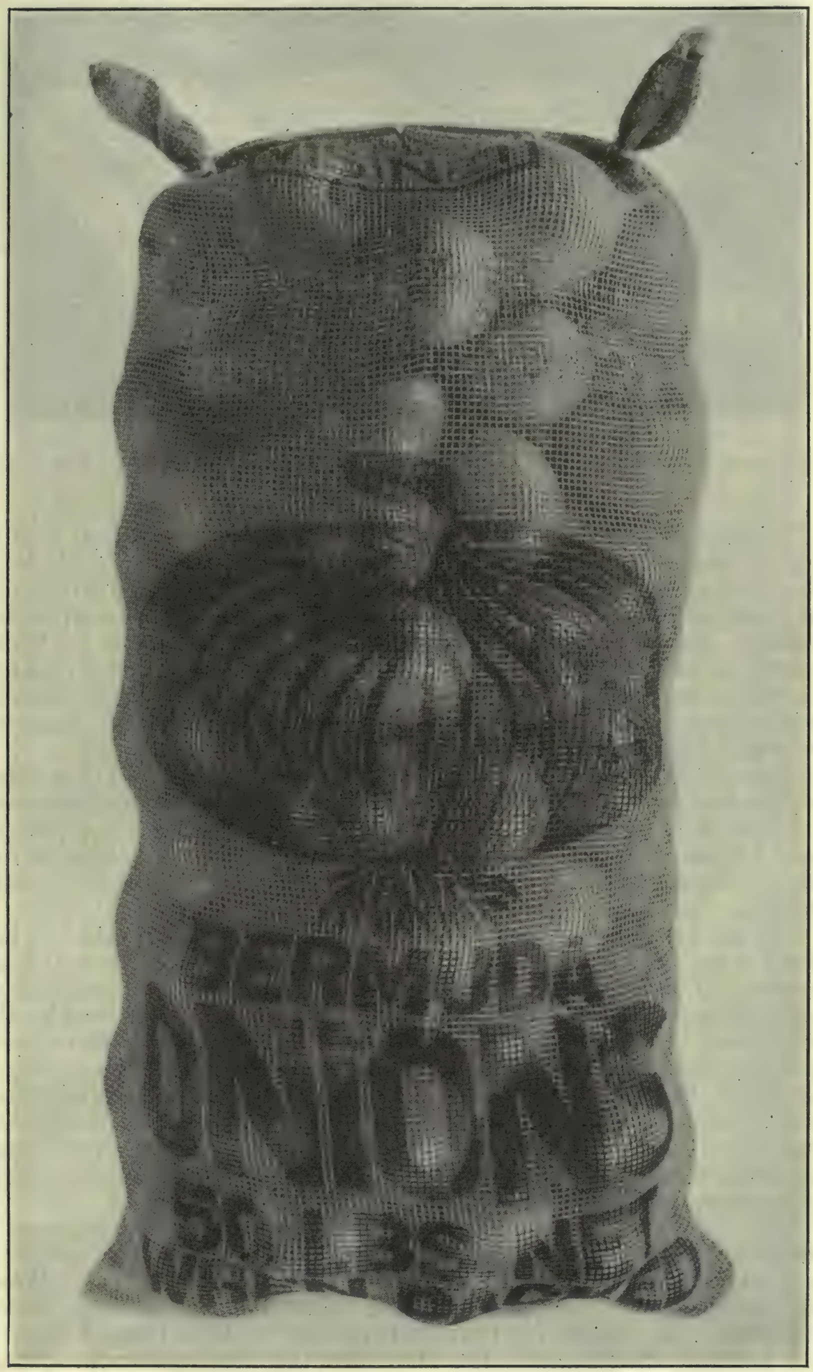
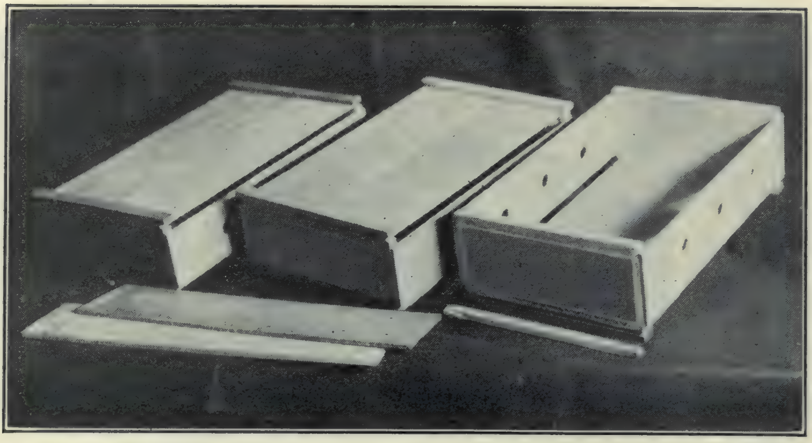
[8] The preparation of peaches for market is discussed in Farmers' Bulletin 1702, Preparing Peaches for Market.


BERMUDA
ONIONS
50 LBS. NET

BAE 33981

Figure 44.—A 50-pound sack of onions.



BAE 4465

FIGURE 45.—Three sizes of western peach or fruit boxes: 4-, 4½-, and 5-inch depths—the last-named has a cleat.

To have numerous peach boxes varying by fractions of an inch in depth, may seem unnecessary and confusing. However, many of these boxes are State standard containers for other products—such as pears, plums, and prunes, persimmons, tomatoes—as well as for peaches (table 7). The California law designates them as "fruit boxes" rather than peach boxes. Under such conditions if the standard width and length are maintained, the use of a number of different depths may be justified so long as the products are graded to standard sizes and packed by count.

Some California peaches are packed in four-basket crates of varying depths and some in lug boxes 5⅙ and 5¾ by 13½ by 16⅛ inches inside.

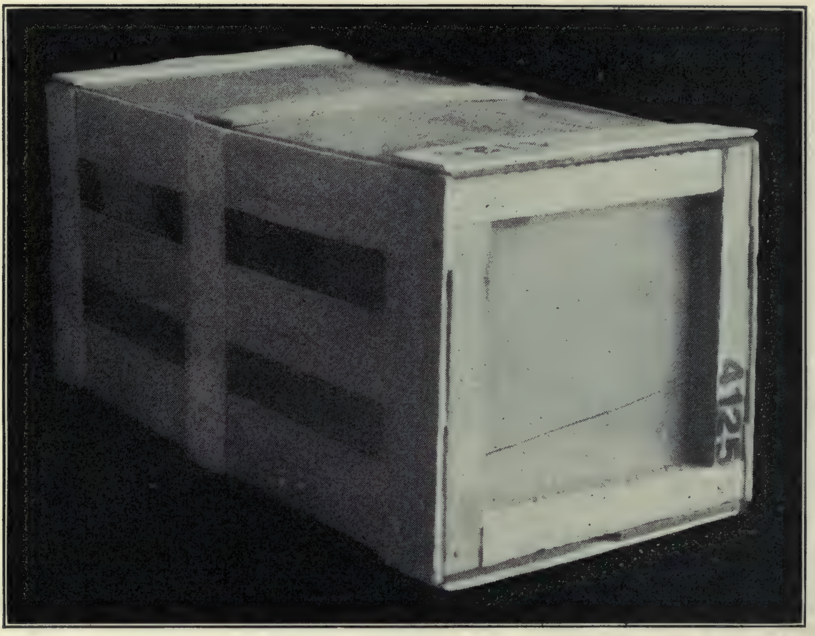
In the country east of the Rocky Mountains the containers chiefly used for shipping peaches are the ½- and 1-bushel straight-side or tub basket, the six-basket crate, and various small sizes of hampers, locally called peach baskets.

The six-basket crate was formerly the most generally used but has given way, to a great extent, to the tub basket. It contains six 4-quart till baskets (fig. 46), placed in two tiers, with a dividing tray between to prevent the fruit in the lower tier from being bruised by the pressure of the upper baskets. The commonly accepted inside dimensions of this crate are 10 by 11 by 22 inches, but a 10½-inch depth is used in Maryland. It is frequent practice to use a half-inch cleat under the cover of the 10-inch crate, to take care of the high bulge with which it is commonly packed. Packing schemes have been developed for the six-basket crate so that it may be packed with a definite number of peaches, depending on their size.

The 1-bushel round-stave basket came into use in Georgia as a container for peaches partly as a result of the high price of packing-house labor. The baskets are jumble packed and ring faced. When the straight-side or tub basket with a removable bottom came on the market it was soon tried in Georgia because it could be packed through the bottom, thus making the ring face the first operation. Later

TABLE 7.—*States adopting standard fruit boxes of specified size*

Kind of fruit box	States adopting boxes 11½ by 18 inches inside with depth of—									
	3 inches	3¼ inches	3½ inches	4 inches	4¼ inches	4½ inches	4¾ inches	5 inches	5½ inches	6 inches
Peaches			Oregon	California, Idaho, Oregon, Washington.	California	California	California	California, Oregon.	Oregon	Oregon.
Pears					do	California, Oregon	do		California	
Persimmons	California		California	California	do	California	do			
Plums and prunes		Idaho, Washington.	do	do	do	do		California		
Tomatoes			Oregon	Oregon, Washington.		Oregon, Washington.		Oregon	Oregon	Do.



BAE 12944

FIGURE 46.—Six-basket crate containing six 4-quart oblong till baskets.

development of the various ring-packing devices has enabled shippers to accomplish the same result without the use of removable bottoms. Consequently, although the loose-bottom basket is still used, all types of tub baskets are now used in the Southeast (fig. 17). The ½-bushel size is used mainly for the smaller sizes and in early shipments.

The tub baskets are also used in Maryland, Delaware, and New Jersey, but this section continues to use many hampers. In New Jersey the 20-quart hamper is popular. It is used without a cover for trucking into Philadelphia, and other nearby markets. The 16-quart hamper is generally used in the Northeastern States. In New York tub baskets are used for shipping, and the 8-quart hamper or "high hat" is used locally. In Michigan and Illinois the straight-side baskets and some bushel boxes are used, and some fancy fruit is packed in the four-basket flat, which holds four 3-quart square till baskets. The western box has not come into any great use in the East, although it has been used to some extent in southeastern sections, particularly in North Carolina.

PEARS

The box for pears has the same inside width and length as the peach and apple boxes, but it is 8½ inches deep. These dimensions are generally accepted in all producing sections, although the States of New Mexico and Washington designate the 8-inch box as standard. The half box, 4½ by 11½ by 18 inches (the same size as the 4½-inch peach box), is standard in Oregon. A special 5½-inch box for pears, provided in the California law, is used for export shipments. The same box and one that is 9½ inches deep are standard in Oregon for three-cushion packs of pears.

The 4¼-, 4½-, and 4¾-inch fruit boxes are standard for pears in California, as are the grape lug and a special lug 6½ by 13½ by 20⅝ inches inside.

In New York, which ships more pears than any other Eastern State, the ½- and 1-bushel tub baskets and the barrel are used. Illinois and Michigan use both round-bottom and tub bushel baskets.

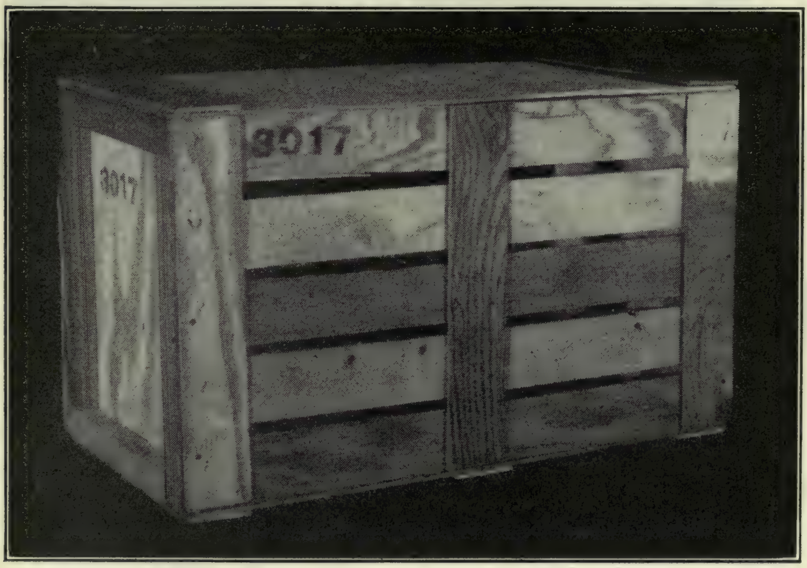
PEAS

In the eastern sections peas are shipped in bushel hampers and in bushel baskets. In the West drums were formerly used to a great extent, followed by the crate, which more recently is being replaced by the 1-bushel hamper (fig. 6). A crate 9½ by 12 by 19⅝ inches inside is standard in Oregon and is used to some extent. The lettuce crate is used locally in California and in Colorado. Some shipments of peas have been made in open-mesh sacks.

PEPPERS

Only one kind of container developed primarily for the shipment of peppers is used in the United States. This is the Florida pepper crate, used in that State for the shipment of peppers and eggplant (fig. 47). As it is also used for the shipment of beets, carrots, turnips, and squash, it may be considered a general-utility crate.

This crate was developed from the 32-quart berry crate, and originally had the same dimensions. As first made, it had a capacity of 1⅗ bushels. Both the berry crate and the pepper crate were changed



BAE 11049

Figure 47.—Florida pepper crate, a desirable general-utility crate of 1½ bushels capacity.

somewhat in measurement, and the pepper crate became 14 by 11 by 22 inches inside, and its capacity a little more than 1$\frac{9}{16}$ bushels. Because of its use as a general-utility crate, it was again changed to hold 1½ bushels by making it 13⅜ by 11 by 22 inches. This crate as used in Texas is 11 by 14 by 22¼ inches inside.

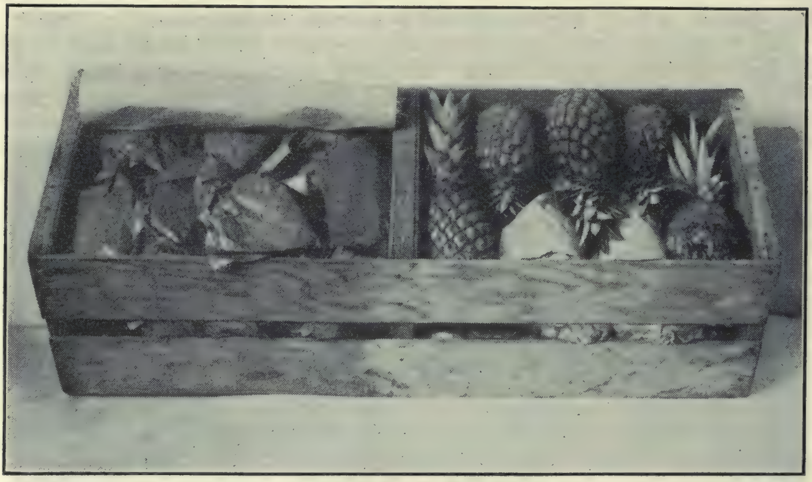
In New Jersey, North Carolina, and Virginia, 1- and 1½-bushel hampers are used for peppers. The western lettuce crate and tomato lug are used in California. In Mexico the lettuce crate with two extra slats is used and in Cuba the Florida crate.

PERSIMMONS

Large persimmons are packed in single layers and the smaller sizes in double layers, much as in the standard peach packs. The boxes standardized by California for persimmons are the fruit boxes ranging from 3 to 4¾ inches deep by 11½ by 18 inches inside; the Los Angeles lug 5¾ by 13½ by 16⅛ inches inside; and the four-basket crate of various depths.

PINEAPPLES

The chief container for pineapples is the standard southeastern crate, measuring 10½ by 12 by 33 inches inside (fig. 48). This is used for shipments from Florida, Cuba, and the Isle of Pines. It is commonly made with panel ends, but some manufacturers use solid heads although they adhere to the inside dimensions given.



BAE 3798

FIGURE 48.—Southeastern standard pineapple crate.

PLUMS, PRUNES, AND APRICOTS

The Italian prunes grown in Idaho are shipped largely in ½-bushel tub baskets, and this package is used to some extent for prunes grown in certain sections of Oregon and Washington. The old "suitcase" lug, approximately 3¼ by 11½ by 18 inches inside, formerly the favorite package for western prunes, and the four-basket crate have been almost displaced by the basket and a display lug. As standardized by Oregon, the dimensions of this lug are 3⅜ by 10½ by 15 inches inside. A ½-inch cleat makes the total depth 3⅞ inches. It is usually packed 16 pounds net weight with one or two faced layers backed by a jumble pack (fig. 49).

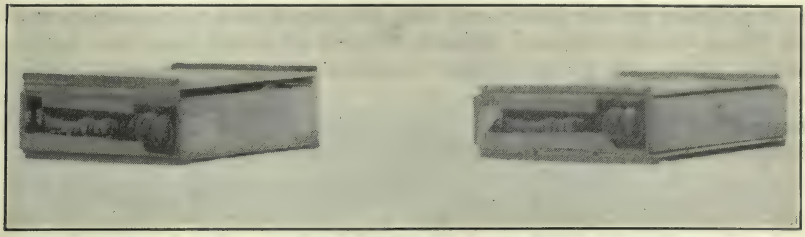

BAE 25122

FIGURE 49.—Northwestern prune boxes. Left, display lug; right, "suitcase" lug.

In California, plums are generally packed in the standard four-basket crate from 4 to 5 inches deep, in two or three layers, depending on the size of the fruit. The count ranges from 112 to 340 per crate. This crate holds four 3-quart till baskets and is 16 inches wide and 16⅛ inches long. Peach boxes (11½ by 18 inches) are also popular, the depth ranging from 3½ to 5 inches and the standard packs varying from 78 to 105 plums per box.

The four-basket crate (see fig. 39) is a popular package for apricots in California. Peach boxes are rarely used, but several special lugs have been developed for faced packs. One is 4¼ by 12½ by 16⅛ inches inside; another has the same depth and length but is 1 inch wider; and a third is 3⅝ by 11 by 14⅝ inches inside, closely akin to the display lug used for prunes and plums.

Eastern plums are shipped in various packages, but ½- and 1-bushel flat-bottom baskets and 4- and 12-quart Climax baskets are probably the most popular. Small plums are occasionally shipped in berry crates.

POMEGRANATES

Two special lugs are used for the shipment of pomegranates from California. One is 5¾ inches deep, and the other 6½ inches deep, the width and length being 11½ by 24⅝ inches in both.

POTATOES

Potatoes are shipped in barrels, sacks, and crates, and in bulk. A few baskets and hampers are also used. Only a few years ago along the southeastern Atlantic seaboard from the Eastern Shore of Maryland, south, barrels of one type or another were used almost to the exclusion of other containers. At present, the barrel is important in Florida, where the double-head type is used (see fig. 1); barrels with cloth or burlap tops are used to some extent in the States farther north.

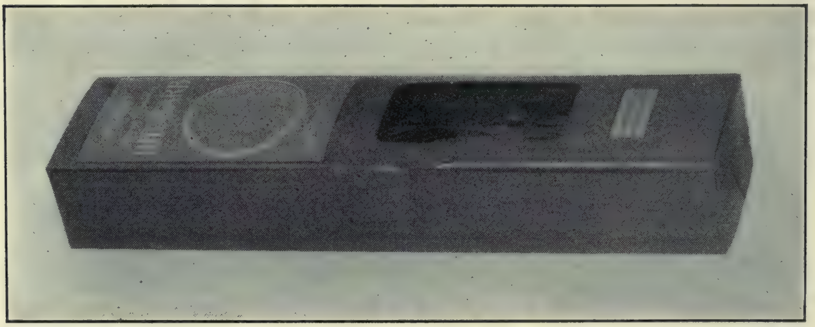
The bushel crate (see fig. 12) measuring 12 by 12 by 15 inches inside, and the 100-pound sack are used in Florida and Texas for early potatoes. In the rest of the country, for both early and late potatoes, the 100-pound sack has become the chief package.

A fairly large volume of potatoes is handled in consumer-size bags of 10-, 15-, and 25-pound capacity. In Maine, Long Island, northern New York, Idaho, Washington, Oregon, and California consumer-size bags are packed in volume. The 10- and 15-pound sizes are most popular in the East, and the 25-pound size is more popular on the West coast. Several different kinds of small bags are used, including those made of cotton sheeting, open mesh, and multiple-wall paper. In some of these States 10- and 15-pound cartons have been used. Baking potatoes are sometimes graded as to size and packed and sold by count in printed cartons.

RHUBARB

It is probable that for rhubarb most growers use whatever packages happen to be convenient, but a few special containers have been reported. For field-grown stock at Walla Walla and Sumner, Wash., a 6-inch peach box 11½ inches wide and 18 inches long is used for packing 20 pounds of rhubarb; the cellar or hothouse rhubarb is usually packed 15 pounds to a box of the same width and length but only 4 inches deep.

The half artichoke box (4⅞ by 11 by 20⅜ inches inside, holding 20 pounds of rhubarb) is used in San Francisco and Alameda Counties, Calif. The northwest apple box, 10½ by 11½ by 18 inches inside, holding 22 pounds, is used around Los Angeles. A box measuring 7¼ by 11½ by 21⅞ inches has been reported in use in Colorado.



BAE 27095

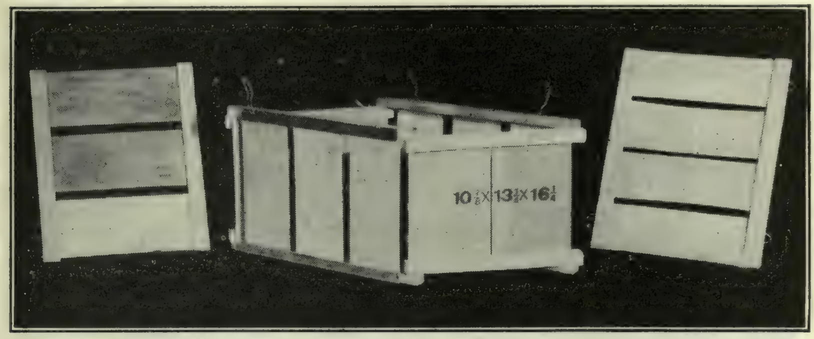
FIGURE 50.—A 2-pound rhubarb carton.

During recent years small folding cartons have come into use in certain eastern sections. One of these measures 2¾ by 4 by 17⅞ inches inside and holds approximately 2 pounds of rhubarb (fig. 50).

SWEETPOTATOES

Sweetpotatoes are shipped to distant markets in hampers, baskets, crates, and barrels. Shipments in sacks and in bulk are confined to local markets. Barrels are used in the Norfolk section for early shipments direct from the field. In the sections of greatest production—in New Jersey, Maryland, Delaware, and Virginia—the two most popular packages for cured stock are the 1-bushel hamper and 1-bushel tub basket. The basket and some crates are used in the Carolinas.

Louisiana has developed a special 50-pound pack of sweetpotatoes using a nailed or wire-bound crate of approximately 1⅛ bushels. Shipments from Alabama are almost entirely in bushel baskets. In Texas both the tub bushel and crates of similar or slightly larger size are used. In Tennessee the 1-bushel hamper and several styles of crates are used. One of these, a folding type, measures 12 by 13¼ by 16¼ inches inside and contains about 38 quarts (fig. 51).



BAE 33592

FIGURE 51.—Folding crate for sweetpotatoes, holding approximately 1⅛ bushels, used in Tennessee.

California has established two boxes as standard for sweetpotatoes, the one-half box—7¾ by 11½ by 22⅜—and the three-fourths box—9¾ by 14 by 22⅜ inches inside, respectively. The Los Angeles lug, 5¾ by 13½ by 16⅛ inches inside, is also used in California.

TOMATOES[9]

Florida leads all other States in carload shipments of tomatoes, followed in order by Texas, California, Mississippi, and Tennessee. In 1935, 22,231 of the 25,240 carloads were shipped by these five States.

At one time practically all tomatoes from Florida were shipped in the six-basket crate, and in a similar way the tapered-end four-basket crate was the chief package in Texas and Mississippi. The former held six 4-quart oblong till baskets, and the latter four 3-quart square baskets. Neither is now used to any considerable extent. The so-called Los Angeles lug is now the predominant package in all important tomato shipping sections (fig. 40). As standardized by California, Oregon, and Texas, this lug measures 5¾ by 13½ by 16⅛ inches inside. An ¹¹⁄₁₆-inch cleat is commonly used on this lug, making the depth 6⁷⁄₁₆ inches, and some types are made with ends of this depth. The usual pack is 30 pounds of tomatoes to the lug.

In Texas, Mississippi, and Tennessee as well as in some other sections a pony or junior lug of the same width and length but only 4⅛ inches deep, holding approximately 20 pounds of tomatoes, is used. Another lug of similar capacity but different dimensions—4¾ by 11½ by 18⅝ inches inside, known as the Sterling lug—is most popular in Union County, Ill.

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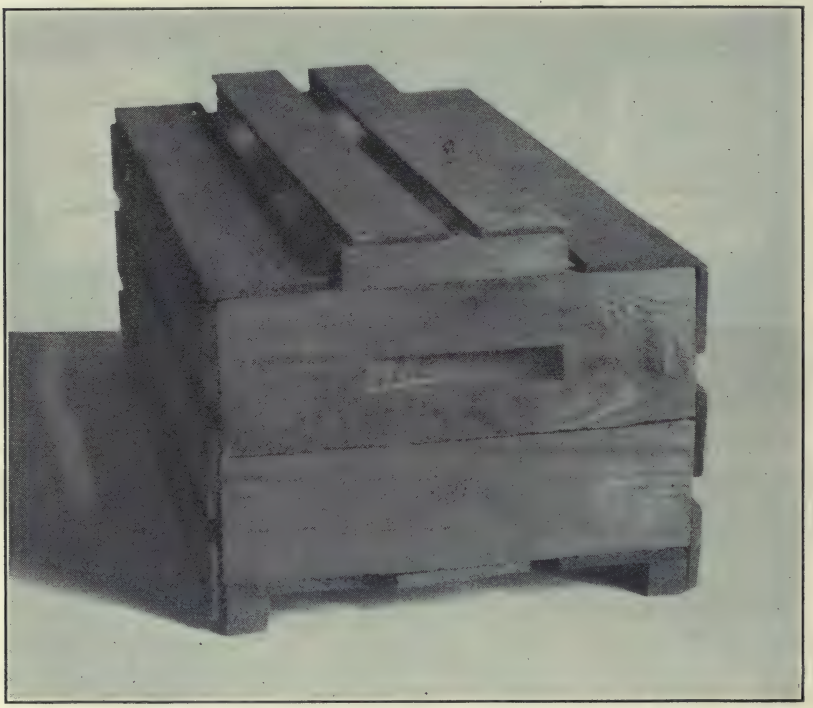
[9] The preparation of fresh tomatoes for market is discussed in Farmers' Bulletin 1291, Preparation of Fresh Tomatoes for Market.

For early shipments from the Imperial and Coachella Valleys of California some use is still made of the standard California four-basket crate. Peach or fruit boxes 11½ by 18 inches and from 3½ to 6 inches in depth are prescribed as standard for tomatoes in Oregon, and the 4 and 4½ inch boxes in Washington.

The New Jersey 20-quart crate (fig. 52) is used extensively in the Swedesboro and southern New Jersey sections. There are some variations in the dimensions of this crate, but representative measurements are 6¾ by 11 by 18⅜ inches inside. The raised central part of the top is a peculiar feature, which would prevent stacking were it not for the bottom rails. This container is sometimes referred to as a 30-pound crate, as it holds approximately that weight of tomatoes. Some dissatisfaction with this crate has been expressed by shippers in New Jersey, and experiments have been made with other crates.



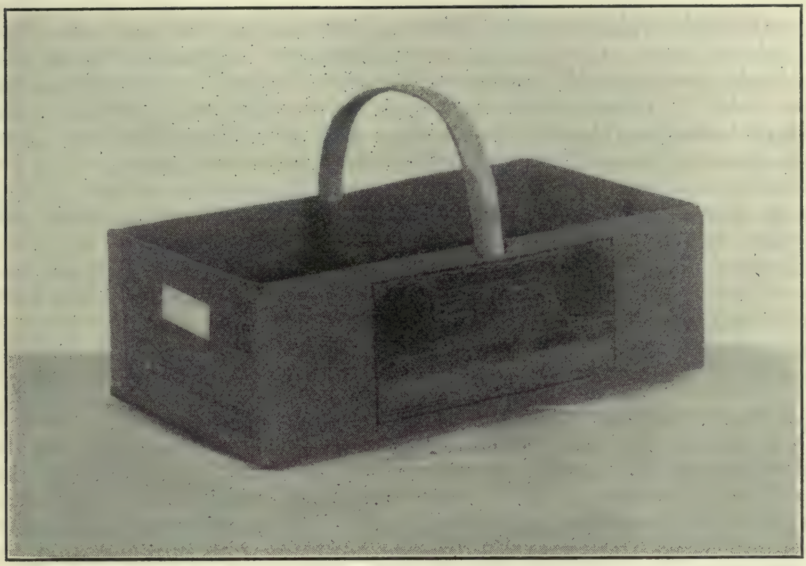
BAE 9579

FIGURE 52.—New Jersey 20-quart tomato crate.

The 12-quart Climax basket (fig. 2) is favored in shipping sections of Ohio, Indiana, and Kansas and is used to some extent in Missouri, Illinois, and New Jersey. With the raised type of cover this basket holds about 20 pounds, and with the flat cover about 17 pounds of tomatoes. The 4-quart and 12-quart Climax baskets have been used somewhat in western New York and in Michigan.

Among other containers that are used for tomatoes are the 20-quart brace hamper and the 8-quart market basket. The former is used in Maryland and New Jersey for trucking tomatoes to canneries and in New Jersey for trucking to the Philadelphia market. The 8-quart square-braid market basket is a common package for hothouse tomatoes in the northern Ohio section and is used for motortruck, boat, and rail shipments.

The most recent package to become popular for tomatoes in this and other hothouse sections, is an 8-quart overhandle paperboard basket of approximately the same dimensions as the 8-quart square braid splint basket (fig. 53).



BAE 24011

FIGURE 53.—An 8-quart overhandle paperboard basket extensively used for hothouse tomatoes and for repacked southern-grown tomatoes.

MISCELLANEOUS FOLIAGE VEGETABLES

For spinach, the 1-bushel basket is the principal package used in practically all commercially important shipping States, among them Texas, Virginia, Arkansas, Louisiana, and Oklahoma.

Besides this package, Louisiana uses a few western lettuce crates and 4-bushel barrels for bunched spinach. From Colorado and California spinach is shipped in western crates.

The packages used for spinach are used also for parsley. The large barrel holds about 20 dozen bunches and two or three layers of ice.

Endive and escarole are shipped from Florida in 1½-bushel hampers, but otherwise, except in California, the 1-bushel basket is used. In California the western crate is used. The basket is also the chief package for kale and collards.

MISCELLANEOUS ROOT VEGETABLES[10]

The western crate (13 by 18 by 21⅝ inches inside) has become the leading package for bunched carrots in California, Arizona, Texas, Oregon, and Louisiana. The half crate (9 by 13 by 21⅝ inches inside) and the 1-bushel basket are also used in Texas and Louisiana, and in the latter State a few 4-bushel barrels are used. In Colorado a half crate is usual.

For bunched beets the western crate and half crate are used in Texas and Louisiana, but the bushel basket is used to some extent in both sections. In Florida shippers use the celery crate, in Virginia a barrel, and in North Carolina a 5-peck hamper. The same containers are used for bunched turnips.

For radishes shippers in Alabama, Mississippi, and Louisiana use a bushel basket and the 4-bushel barrel. In Arkansas, Texas, and Colorado the one-half lettuce crate and a smaller crate measuring 8 by 12 by 22 inches inside are used. In South Carolina and Virginia a bushel crate or the bushel hamper and sometimes the New York lettuce crate measuring 7½ by 16 by 19 inches are found.

Shallots are shipped from Louisiana in the western crate and half crate, the 4-bushel barrel, and a 1⅓-bushel crate. In Texas the western crate is used, and in Virginia the bushel hamper.

Topped beets and carrots are usually marketed in 50- or 100-pound bags but 1-bushel baskets are commonly used in New York and Illinois.

BENEFITS ACCRUING FROM FEDERAL STANDARDIZATION

Great variation is found in fruit and vegetable containers. Some of this is practically unavoidable because different commodities require different types of packaging and packages and because manufacturers in different sections of the country can readily supply certain kinds of containers and cannot readily supply other kinds. For various reasons it is not likely that in a country as large as the United States one specific type of container will be adopted for any given product.

But some reduction in the number of kinds of containers now in use is possible. The vast interchange of fruits and vegetables is acquainting the various shipping sections with the containers used in other sections, and out of this is likely to come a more general adoption of those containers that appear to be best suited to the successful marketing of given products. The almost universal use of the lug box for tomatoes and a similar widespread use of the western-type lettuce crates for cabbage and other vegetables indicate the possibilities. Among the contrary forces are inertia, local pride and prejudice, sectional differences in materials and in methods of manufacturing, lack of authentic information, and lack of centralized and authoritative leadership.

Certain highly specialized products may require special containers, but for the great mass of perishables moving in all directions across the country by motortruck and rail, economical handling, fair competition, proper accounting, and informative reporting are contingent upon the use of established units of fixed and uniform value. The coming into use throughout the country of a given type of container intensifies rather than diminishes the need for fixed standards, if sharp practices and deceptive sizes and shapes of containers are to be avoided.

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[10] The preparation of bunched beets, carrots, and turnips for market is discussed in Farmers' Bulletin 1594, Preparation of Bunched Beets, Carrots, and Turnips for Market.

The benefits accruing from the Federal standardization of hampers, baskets, and barrels are generally recognized, and it is believed that the principle of standardization—simplification—could be applied to those containers not now regulated on a national basis with results equally advantageous to all concerned. In this field it is fundamental that the problem of standardization be seen as a twofold question. (1) There must be standards that are based on the bushel with its multiples and subdivisions for use in shipping produce which is sold extensively by the bushel or by measure and for which standardized baskets and barrels are now used, and (2) there must be standards that are not based on volume but rather on their particular desirability for use in packing certain products by weight or numerical count.

When measurement by volume is the primary consideration, the standards established by the Federal Barrel Act and the two Standard Container Acts would seem to be adequate for competitive types of containers. As to the containers for commodities packed by weight or count, the work of standardization and simplification should be carried on by some centralized authority in collaboration with the industries affected, with a view to minimizing the number of shapes and sizes of containers, obtaining uniformity in the dimensions thereof, and properly identifying and designating them.

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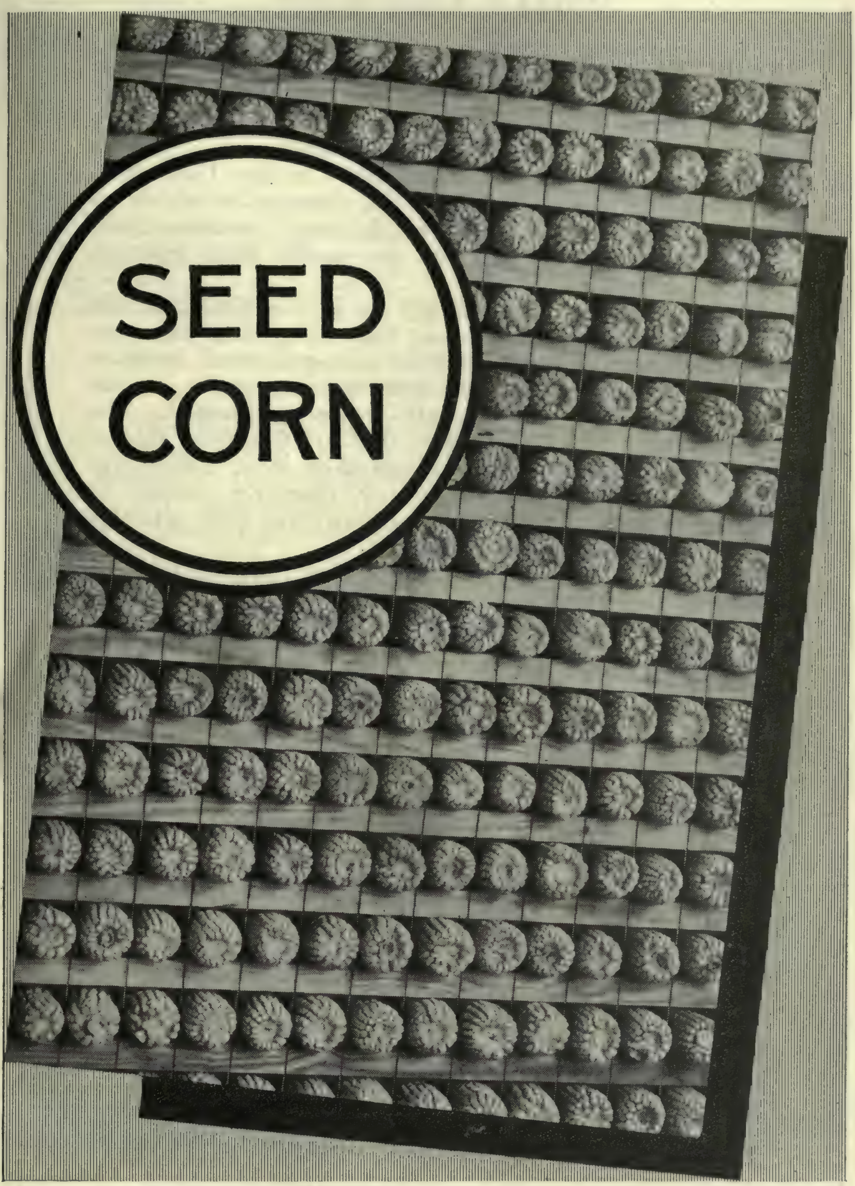
SEED CORN



FARMERS' BULLETIN No. 1822
U. S. DEPARTMENT OF AGRICULTURE

THE USE of good seed corn would materially increase the yields commonly obtained by many farmers. By good seed corn is meant well-selected, viable seed of a productive strain that is adapted to the locality.

Corn hybrids are expanding rapidly in the Corn Belt, but there are many sections of the country for which no adapted hybrids are available. In these sections open-pollinated varieties maintained by careful mass selection offer most promise.

Mass selection is outstandingly the best method that can be recommended at the present time for general farm use for the selection of seed corn from open-pollinated varieties.

Field selection of seed corn from standing stalks is absolutely essential if the best results are to be obtained. The grower should select sound ears that are free from disease and insect damage and have matured on erect, disease-free plants. Narrow selection for any character should be avoided, as past experience has shown that such selection always results in reduced yields.

Seed corn should be picked as soon as the crop has matured; it should be promptly dried to 12- to 14-percent moisture and stored in a cool, dry place and protected from damage by grain moths, weevils, and mice.

Seed corn that has matured normally and been quickly dried and properly preserved will grow satisfactorily. It is well, however, to make certain of the viability by a preliminary germination test before the seed ears are shelled.

Individual shelling of the ears and inspection of the seed from each ear before it is added to the bulk seed lot are recommended.

The seed should be graded for size to obtain the most uniform drop with planters, particularly those of the edge-drop type.

The treatment of seed corn with any of the mercury dusts manufactured for that purpose is recommended under some conditions.

This bulletin supersedes Farmers' Bulletin 1175, Better Seed Corn.

Washington, D. C. Issued April 1939

SEED CORN

By MERLE T. JENKINS, *principal agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry*

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INTRODUCTION

THE AVERAGE YIELD of corn for the entire United States for the 10-year period 1927–36 was only 22.9 bushels per acre. In many sections of the country yields of two, three, or even four times that quantity frequently are produced with only such labor and expense as are entirely warranted in practical corn production. The use of inferior seed is one of the important factors contributing to the low yields commonly obtained by many farmers. Losses from this source may be readily controlled if proper attention is given to the choice of an adapted, high-yielding strain and to the selection and care of the seed.

Each spring good seed corn is scarce. This condition is entirely unnecessary in most seasons. It usually is because of negligence or delay. If a 2-year supply of seed were saved each fall there would be no shortage of good seed even following the occasional seasons when little sound corn is produced.

This bulletin discusses the essentials in the selection and care of seed of open-pollinated varieties of corn. It is intended primarily for the grower who maintains and seriously endeavors to improve his locally adapted strain of open-pollinated corn by careful mass selection.

In the Corn Belt the use of hybrid seed corn is increasing rapidly. The breeding and development of corn hybrids is a specialized undertaking and will not be discussed in this bulletin. The subject is fully covered in Farmers' Bulletin 1744, The What and How of Hybrid Corn. However, many of the procedures and precautions to be observed in the harvesting, drying, and storing of any seed corn necessarily must be observed in the handling of seed of corn hybrids if a product of high quality is to be obtained. Such items are discussed in the following pages.

CHOICE OF STRAIN

Corn is grown in every State, from sea level to high elevations, from regions with more than 100 inches of rainfall annually to others with less than 15 inches, and from the Southern States with their extremely long growing seasons and short summer days to the Northern States which have relatively short growing seasons and long summer days.

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It is only natural, therefore, that enormous differences should exist among the strains from different sections of the country and that regional adaptation should be of first importance in the selection of the strain for planting.

In this connection it should be emphasized that varietal names of corn mean less than those of almost any other field crop. Because of its cross pollination, corn is maintained in an extremely heterozygous condition. Even the most carefully selected varieties of corn are such mixtures that they are changed readily by selection under a new environment. Variations in the ideals and methods of selection of different breeders have resulted in the development of innumerable strains within all of the important varieties. In fact, it often has been shown in yield trials that there may be larger differences among strains within a variety than among varieties of the same seasonal requirements. These facts simply emphasize that in choosing the strain of corn to plant, the important thing is to know that the particular strain in question has performed well in the given locality or under similar soil and seasonal conditions.

The agricultural experiment stations in nearly all States have data available as a result of their varietal yield tests, which are used as a basis for their recommendations of the strains of corn best suited for planting in the different sections of their States. In most cases they maintain up-to-date lists of reliable growers of the strains of seed they recommend for planting. This information usually is placed in the hands of the county agricultural agents. Accordingly, those interested in the best available information on this subject should consult their local county agricultural agent or write to the agricultural experiment station in the State where they expect to grow the crop.

SHOULD THE AVERAGE GROWER OF OPEN-POLLINATED CORN BUY OR SAVE HIS OWN SEED?

Many farmers annually buy all of their seed corn; others buy only enough every few years for a special seed plot and produce their own seed for main-crop planting; still others maintain their own strain and save all of the seed required for their own needs. The choice of plan in each particular case will depend on whether the farmer has the time and ability to produce as good seed and care for it as well as the person from whom he buys.

Corn breeding requires a special interest in the crop and an attention to the details of selection that farmers generally do not have the time to apply. The farmer who is not willing to make the effort necessary to maintain the productivity of his own variety will do better to obtain his seed year after year from a reliable producer of an adapted strain of proved performance, if such a producer is known. Unless seed from a reliable producer is available, however, the best place for the farmer to obtain seed corn is from the fields on his farm that were planted with a strain which has generally proved successful in the locality. Or he may be able to get such seed from a neighbor.

A conscientious seed-corn breeder may render real service to his community, for which he should be adequately compensated. A bushel of seed will plant from 4 to 8 acres, depending on the variety and locality. Only a small increase in productivity is needed, therefore, to pay good dividends on an investment in superior seed corn.

METHODS OF CORN IMPROVEMENT

The two important methods of corn improvement in use at the present time are: (1) Mass selection among open-pollinated plants, and (2) selection in inbred lines for use in the production of corn hybrids. For many years the ear-to-row method of breeding was popular and very widely used, but as the results were disappointing it now has passed out of use. Mass selection is the only breeding method that will be discussed in this bulletin.

MASS SELECTION

Mass selection consists in choosing certain desired individuals from the main crop and bulking the seed harvested from them. It has been amply demonstrated that when consistently and intelligently used over a period of years, this method of breeding will radically modify practically any or all characteristics of the plant and ear. The rate of change in an open-pollinated crop, such as corn, is not so rapid with mass selection as with certain other methods of breeding. In spite of its limitations, however, it is outstandingly the best method that can be recommended for general farm use in the selection of seed corn from open-pollinated varieties.

A certain amount of mass selection probably has been practiced since the very earliest times. Corn ears are large, and they usually have been handled individually, both at harvest and when shelled for seed. Under these circumstances some selection among the ears is inevitable.

Nearly all of the present varieties of corn have been developed by mass selection through the painstaking efforts of competent, interested breeders. Reid Yellow Dent, developed in central Illinois by Robert Reid and his son, James L. Reid, during a lifetime of conscientious selection, is a typical example. Neal Paymaster, a two-eared variety developed by W. H. Neal, of Lebanon, Tenn., after many years of carefully selecting seed from two-eared plants, is another typical example from a different section of the country. Numerous other examples of this sort might be given.

Corn breeders of the past have differed widely in their ideas of what constituted a good variety of corn. Hence, the wide diversity of types represented by the present well-selected varieties. They have differed also in their ability to develop productive strains, as has been demonstrated in practically every State in yield comparisons. Farmers who obtain seed of well-bred varieties also differ greatly in their ability to select seed from these varieties and maintain or improve their yielding capacity. This is well illustrated in the differences in yielding ability of different strains of Reid Yellow Dent reported by the agricultural experiment stations of Iowa, Illinois, and other States and in similar differences among strains of Neal Paymaster reported by the Tennessee Agricultural Experiment Station and by other stations in the Southern States.

FIELD SELECTION OF SEED CORN

The field selection of seed corn from the standing stalks is absolutely essential if the best results are to be obtained. Field selection provides an opportunity to inspect the plant from which each seed ear comes, to observe its characteristics, and to evaluate its general desirability for breeding purposes. It is true that such minor and unimportant characteristics as ear type or kernel type may be modified by careful selection of seed ears from the crib. However, the important characteristics of the plant, its productivity, disease resistance, insect resistance, and general adaptation to its environment can be modified intelligently only by careful field selection.

Seed corn should be picked as soon as the crop has matured. The gathering of seed corn should be made a special and all-important task when it is ripe. In the Northern States there is always danger of injury to the seed by freezing weather if it is left in the field. Although the dangers of loss from this cause are not important in the South, serious damage in that section may result from insects and disease if the seed is not harvested promptly. Bags, such as are shown in figure 1, are very convenient for field picking.

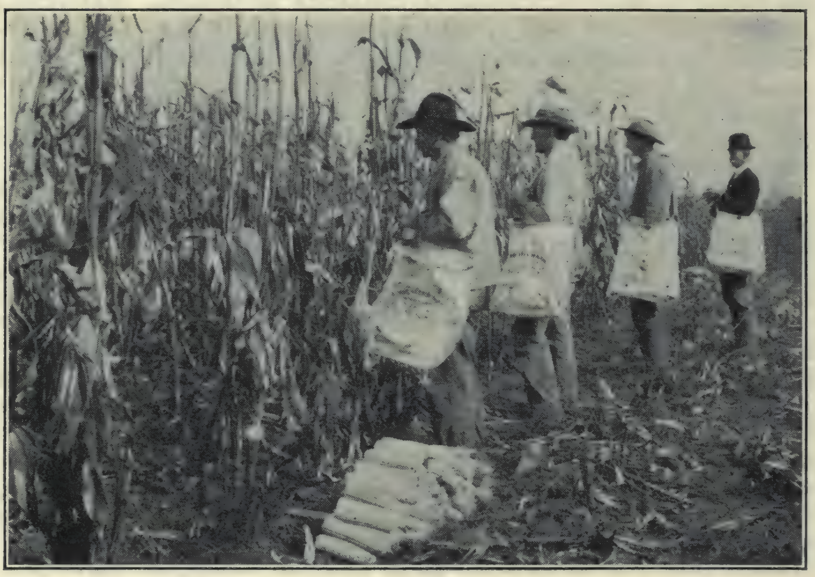

FIGURE 1.—Bags like those shown above are very convenient for use in selecting seed from standing stalks in the field.

It is a good practice to field-select more seed in the fall than actually will be needed for spring planting. A little extra seed is added insurance against a real shortage in case of accidental losses that may occur during storage. Extra seed also will permit the discarding of ears which, though apparently healthy when harvested, show disease when shelled.

Occasionally very unfavorable seasons occur in which the crop is subjected to severe conditions, such as high temperatures, drought, frost injury, insect attacks, or disease. Seed matured by the plants that are able to survive these adverse conditions is especially valuable and should be saved and increased. Such plants represent the hardiest individuals of the variety and those that were able to reproduce under the particular vicissitudes of the season. There is always a tendency, however, for farmers to discard the poor-looking seed that survives a bad season and obtain new and often poorly adapted seed from other areas.

CHARACTERISTICS OF A DESIRABLE PLANT

While plant type varies widely in the different corn-growing areas, the following general suggestions will apply to most all sections:

1. Seed ears should be taken only from plants that have produced heavily in competition with a full stand of vigorous plants. Avoid large ears on stalks standing singly with an unusual amount of space around them.

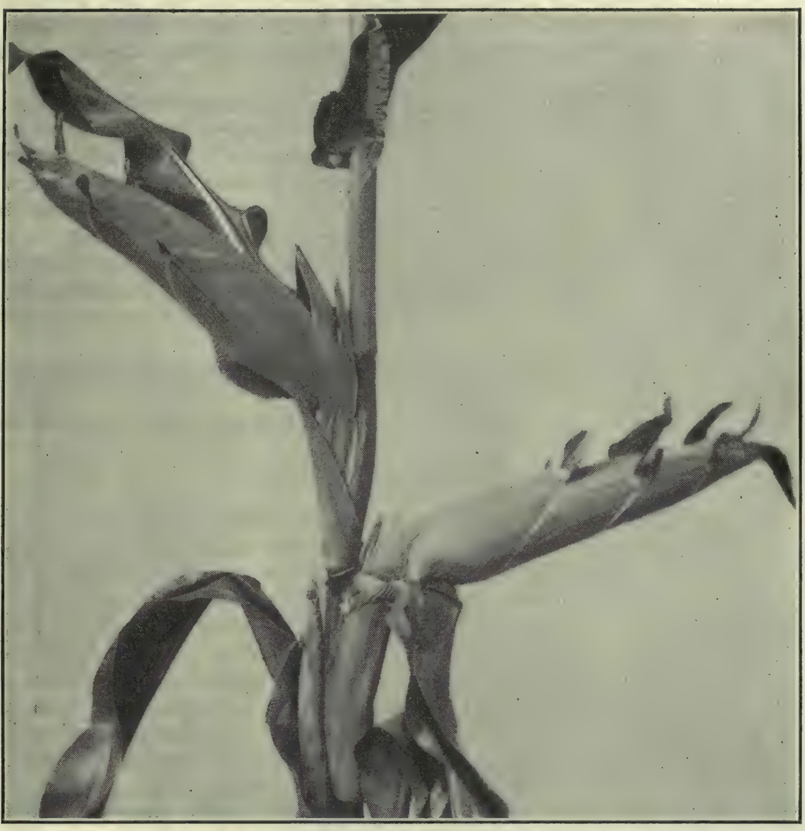

Figure 2.—A typical stalk of a prolific variety of corn, showing two good ears well balanced on the stalk. The number of ears per stalk can be modified by selection.

2. The plants and ears should be free from disease, such as smut, ear rot, stalk rot, and root rot. The shank scar should be light in color and should show no shredding or dark discoloration.
3. The plant should be erect and have a well-developed root system as indicated by good anchorage in the soil.
4. The plants should be of medium height for the variety, and the ears should be at a convenient height for husking.
5. The stalks should be of medium size for the variety and should not have an excessive number of tillers.
6. The leaves should remain deep green in color and of good texture until the ear is ripe. The number of leaves should be about average

for the variety in the locality. Avoid selection to develop strains with excessively large or excessively small leaf area.

7. The number of ears per stalk should be typical of the variety. Prolific varieties should have two or more good ears per stalk (fig. 2). All of the ears on any one stalk are of equal value from the breeding standpoint.

8. The shanks of the ears should be of such length and strength as to permit the ears to hang over with the tips down, but broken or diseased shanks should be avoided. Long shanks also should be avoided. In prolific varieties long shanks may permit the lower ears to touch the ground.

9. The husks should be of good texture and extend well over the tip of the ear. In the South, good husks are very important as they may be a considerable protection against insects. To afford the most protection, they should be thick and close fitting. The tendency to fit the ear closely is greatly increased if the individual husks are wide enough to reach entirely around the ear and overlap slightly.

10. The ears should be sound, well-filled, and heavy for their size. Avoid narrow selection for any particular ear type. Past experience has shown that narrow selection for any ear type will reduce yielding ability.

11. The kernels should be well filled and mature. They should not be excessively rough or starchy.

12. The germs should be large, clear, and plump, with no indication of rotting.

DRYING SEED CORN

Seed corn should be placed where it will start to dry the day it is gathered. A free circulation of air is essential if seed corn is to be properly and promptly dried. Under many conditions heat will be found beneficial. In the cooler climates, heat may be necessary to dry the corn and protect it from freezing weather until dry. In the more southern sections there may be little or no danger from frost, but the humidity often is high in the fall, and the corn dries very slowly. In warm weather if the humidity is high the seed ears may be overrun with mold before they dry unless a little circulating heat is provided. This is particularly true if the ears are not stored on hangers or racks where they cannot touch one another.

If heat is employed it is especially necessary that the room be well ventilated. Heat in a poorly ventilated room may do the seed more harm than good. The fire should be slow and, if possible, should be situated well below the ears, which should have good ventilation above them. With good ventilation, quick and satisfactory drying will be obtained at a temperature of about 100° F. The temperature should in no case be allowed to go above 110°, as it may result in injury to the seed.

Small quantities of seed, or even lots containing as much as 500 bushels, may be dried satisfactorily on hangers or racks, of which there are numerous kinds. Any arrangement that will hold the ears so that they do not touch one another should be entirely satisfactory.

For small quantities of seed, temporary hangers made of binder twine or cord, such as are shown in figure 3, may be used.

Wire racks like those shown in figures 4 and 5 are more convenient and in the end cheaper than hangers made of binder twine or cord. A method of cutting electrically welded fencing into racks without waste is shown in figure 5. Fencing having horizontal wires 4 inches apart and upright wires 2 inches apart may be obtained in widths of 2, 3, and 4 feet. Dealers can usually supply such fencing to farmers at an initial cost of about 10 cents for each bushel of seed suspended. These racks will last many years and are light and easily stored when not in use.

Racks as shown in the cover page illustration may be made conveniently by nailing 2-inch cross strips on 2- by 4-inch uprights. The ears are separated by vertical wires. Similar racks may be made from woven or welded fencing wire. Wire having a mesh 3 inches square is preferable, as it provides an individual space for each ear. Such a rack is shown in figure 6.

Where large quantities of seed corn are to be dried, the Wisconsin bin method of drying, or some slight modification of it to fit the individual conditions, will be found most satisfactory. In this method, developed by the Wisconsin Agricultural Experiment Station in 1926, the ears are piled in bins to a depth of 6 or 7 feet. The bins have slatted false bottoms and are made so that they may be tightly closed. Warm air from a furnace, heated to about 110° F., is forced into the bins with a multivane blower large enough to move the air through the corn at a rate of about 70 feet a minute. The bins and airways are designed to permit reversing the direction of the air flow through the corn as desired. Various modifications of this method are in use.

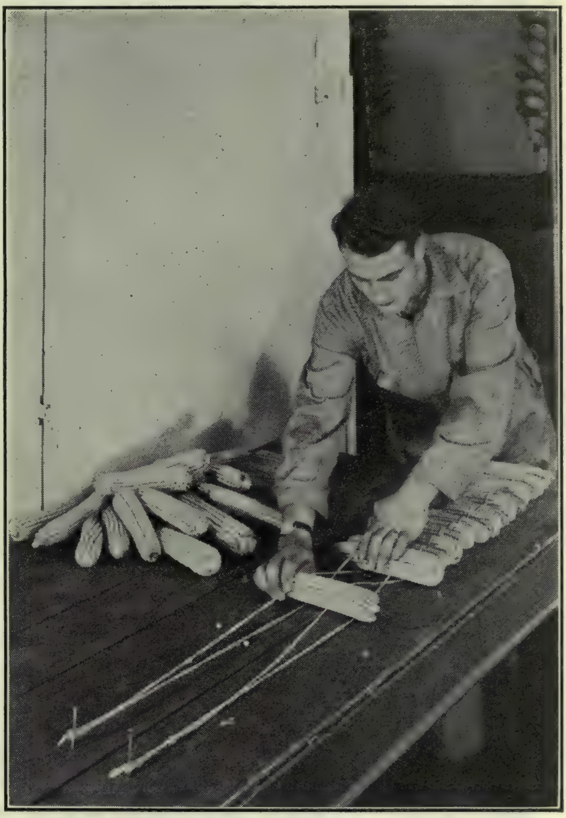

FIGURE 3.—Temporary hangers of binder twine or cord used for drying small quantities of seed.

The bin method of drying is intended primarily for those who make a commercial business of producing seed corn. It is most economical for lots of 500 bushels or more. Consequently, it is not practical for the farmer who produces seed corn only for himself.

Seedsmen wishing information on the Wisconsin bin method of drying seed corn should consult their State agricultural experiment station or write directly to the Wisconsin Agricultural Experiment Station, Madison, Wis.

WINTER STORAGE OF SEED CORN

When the ears are sufficiently dry so that they contain not more than 12 to 14 percent of moisture, they should be stored in a cool, dry place where they will be protected from mice or insects. In the Northern States, if the seed-drying room is mouseproof, the ears may remain on the hangers or in the bins where they were dried. This is never feasible in warm climates or in storage buildings that remain warm throughout the winter, because of the danger of damage by grain moths and weevils. The seed must not be exposed to high temperatures or to damp atmospheres. Both of these conditions injure viability.

PREVENTING INJURY BY WEEVILS OR GRAIN MOTHS

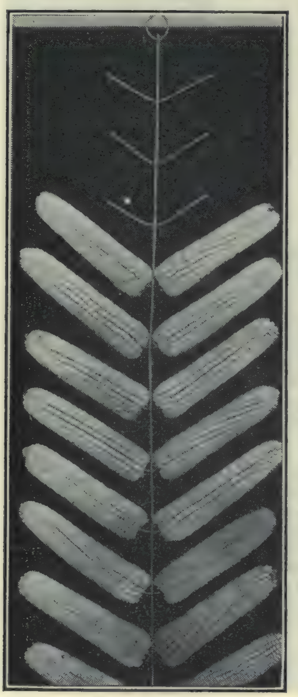

FIGURE 4.—Seed ears suspended by means of wire racks made from electrically welded fencing. Figure 5 shows how these racks may be cut.

In localities where weevils and grain moths injure stored grain, the dry seed ears should be stored in tight receptacles, with 1 pound of moth balls or flake naphthalene enclosed for each bushel of corn. This quantity tightly enclosed with the corn will prevent damage from those insects and will not injure the seed.

The material will cost about 10 cents a pound. One dollar's worth will protect seed enough to plant 60 acres.

If at any time weevils or grain moths on the dry seed ears show evidence of getting beyond control of the moth balls or flake naphthalene, the ears should be enclosed in airtight rooms, bins, boxes, or barrels and fumigated with carbon disulphide for 48 hours. The carbon disulphide should be placed in shallow dishes or pans on top of the seed. A half pound is sufficient for a box or barrel holding 10 bushels or less. In larger containers, such as airtight rooms or cribs, 8 to 25 pounds of carbon disulphide per 1,000 cubic feet of space is enough for thorough fumigation. The amount of fumigant necessary depends on the temperature of the grain and the tightness of the container. The cooler the grain the larger the dosage that is required. Fumigations at temperatures below 60° F. are not highly effective.[1]

Carbon disulphide is a highly inflammable liquid and should be handled with extreme care. The greatest danger with this material is due to its highly inflammable vapors which form explosive mixtures with air. The vapors are heavier than air and may travel a considerable distance to a source of ignition and flash back to cause an explosion.

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[1] Additional information on fumigating corn with carbon disulphide and information on the use of noninflammable fumigants in cases where the fire hazards might make carbon disulphide unsafe are given in Farmers' Bulletin 1483, Control of Insect Pests in Stored Grain, and in Farmers' Bulletin 1811, Control of Insects Attacking Grain in Farm Storage.

Carbon disulphide vapors can be ignited by any kind of flame, such as a lighted lantern, sparks from electric switches or motors, and lighted smoking materials. The vapors also may be ignited by a hot steam pipe, or a heavy blow such as may be struck by a hammer, or by heated grain where the temperature rises to the ignition temperature of the vapors.

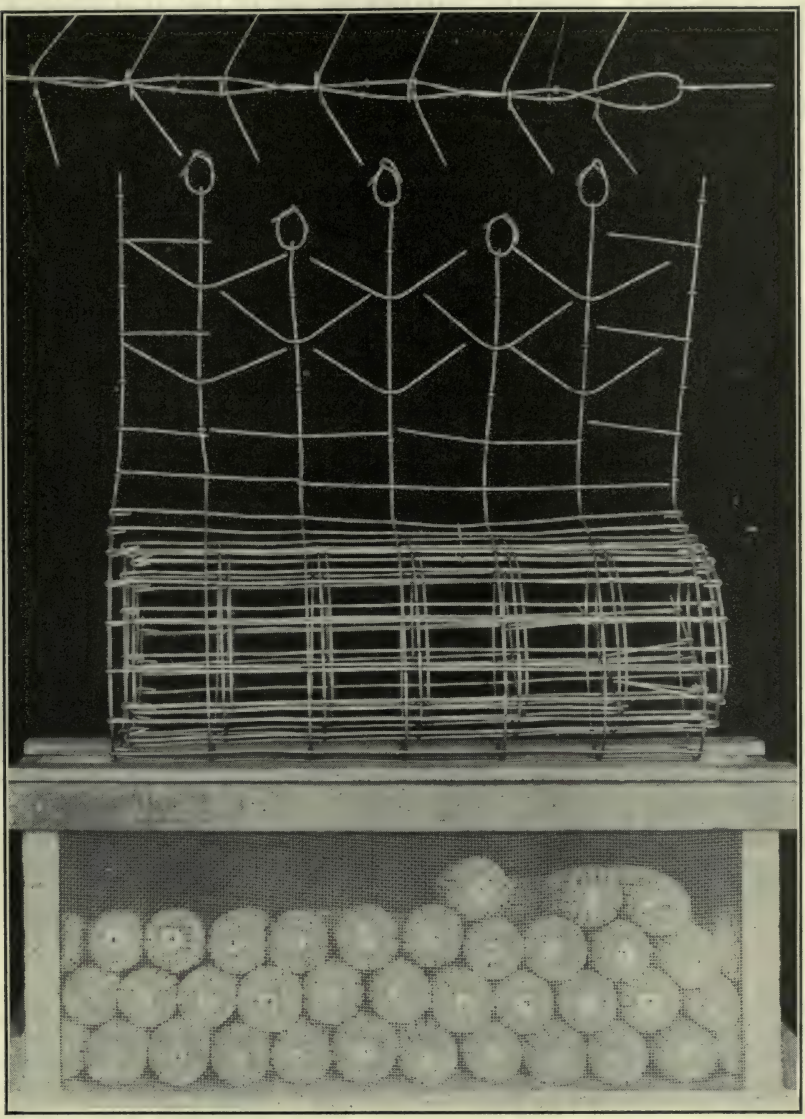

FIGURE 5.—Seed-corn racks made from electrically welded wire fencing, showing the method of construction; also a mouse-proof crate for storing seed corn in winter.

From a fire and explosion standpoint, carbon disulphide is much more hazardous than gasoline. Because of the fire hazard involved, most insurance companies prohibit its use in buildings covered by their policies, except in certain cases and then only under conditions imposed by the insurance companies.

It always is desirable to handle the seed in such a manner that this more extreme treatment is unnecessary, as it may injure seed of high moisture content.

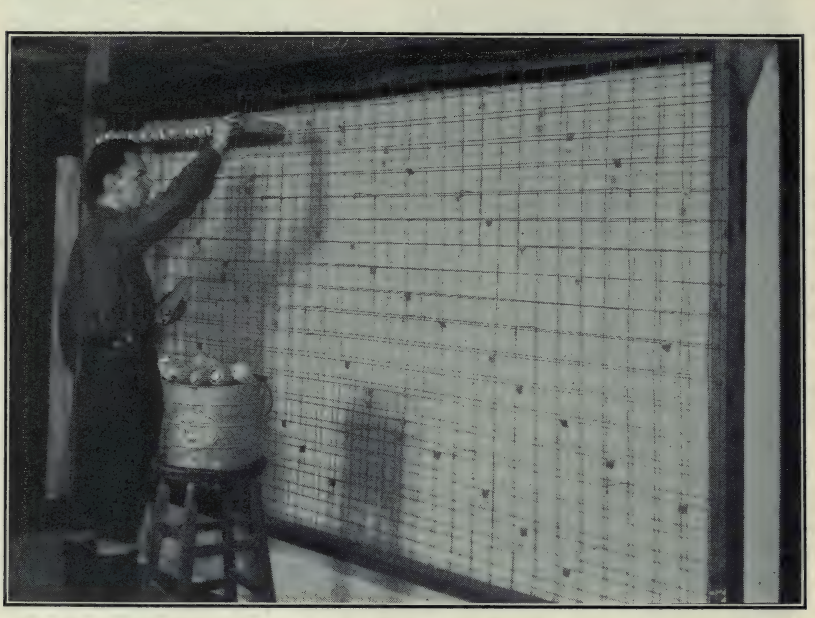

FIGURE 6.—Seed-corn rack made of electrically welded wire with a mesh 3 inches square.

WARNING!

Carbon disulphide is highly inflammable. Extreme care should be taken to insure against fire.

TESTING THE GERMINATION OF SEED CORN

Seed corn that has matured normally and been dried quickly and properly preserved will grow satisfactorily. It is very poor management to neglect proper preservation and as a result have to spend time in the spring separating by germination tests ears that have been badly damaged from those that have been slightly damaged. Prevention is better than cure, and in many cases cure is impossible.

Ears slightly damaged by poor preservation may germinate 100 percent but will produce less than if they had received better care.

Before shelling the ears, it is wise to test separately 10 kernels from each of 100 ears in a rag-doll tester or seed-corn testing box. Be sure that the kernels tested were not injured when removed from the ear.

If 3 or more kernels out of 10 from any ear fail to grow, it will be advisable to test every ear before planting. If the seed has been properly selected and preserved, the 100 ears tested will seldom reveal any of low viability, and further testing of the supply will be unnecessary.[2]

SHELLING SEED CORN

The first operation in shelling seed corn properly is to remove the small kernels from the tips of the ears. The round, thick kernels from the butts may or may not be removed preparatory to shelling. The small tip kernels complicate the grading of the seed for size and are more likely to be diseased than the other kernels of the ear, and hence frequently are less productive. The round butt kernels are as productive as the other kernels of the ear but may not drop as uniformly through standard planter plates. When they are not removed prior to shelling they usually are separated from the more uniform kernels on the central portion of the ear by grading for size.

It always is desirable to shell seed ears separately and examine the shelled grain from each ear individually before it is added to the general seed supply. Many ears may be found the kernels of which look perfectly healthy and of good quality while on the ear but on shelling show disease, poor germs, "silk cut," or other undesirable characteristics. The seed from a large ear sometimes will plant as much as one-tenth of an acre, and the inclusion of the seed from only a few bad ears may cause considerable loss in yield.

Small lots of seed corn are best shelled carefully by hand. Each ear should be shelled separately into a sieve,[3] any worm-eaten or blemished kernels being rejected. If the seed from an ear appears good and contains no poor kernels, it should be poured into the general supply and another ear shelled in the same way.

Hand shelling is not practicable for large lots of seed corn. For such lots a one-hole hand or power sheller may be used. Extreme care should be exercised to insure that the sheller does not break or crack an undue number of kernels. When a sheller is used the ears should always be shelled separately into a pan, sieve, or other receptacle, or spaced on a flat, moving belt so that the seed from each ear may be examined and rejected if necessary before it goes into the general seed supply.

GRADING SEED CORN FOR SIZE

The kernels from different ears of corn vary widely in size and shape. It will be found that most corn planters will drop the seed more uniformly if it is carefully graded for size. This is especially true of those with the edge-drop type of planter plates.

Where only a small quantity of seed corn is to be used, much of the grading for size can be done before the ears are shelled. After the butt and tip kernels are removed, the ears may be separated into lots on the basis of kernel size. These lots may be shelled separately, run over a small hand grader such as is shown in figure 7, and tried out in the corn planter. The lots may be numbered to correspond with the number on the planter plates found to drop them most uniformly.

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[2] Complete directions for testing seed corn are given in Farmers' Bulletin 948, The Rag-Doll Seed Tester.

[3] A large sieve with quarter-inch mesh and a concave bottom screens the chaff from the kernels and is easily emptied.

These arrangements can be completed before the rush of spring work begins.

Large lots of seed corn, particularly of seed of corn hybrids, present an entirely different and much more complex problem of grading for size. When large lots of seed corn are shelled the butt kernels usually are not removed prior to shelling. Occasionally in the production of hybrid seed corn, poor pollination will result in a rather large percentage of round or misshapen kernels. The various corn hybrids also have a natural range of kernel sizes and shapes much greater than the common open-pollinated varieties.

In grading large lots of seed corn for size it is a good practice to run the seed as it comes from the sheller first through a fanning mill fitted with a large screen to remove all pieces of cob and other coarse material and a small screen to remove all dirt, chaff, and any very small kernels. The clean seed from the fanning mill may next be run through a corn grader (the squirrel-cage type is most commonly used) and separated into three to five lots on the basis of kernel size and shape.

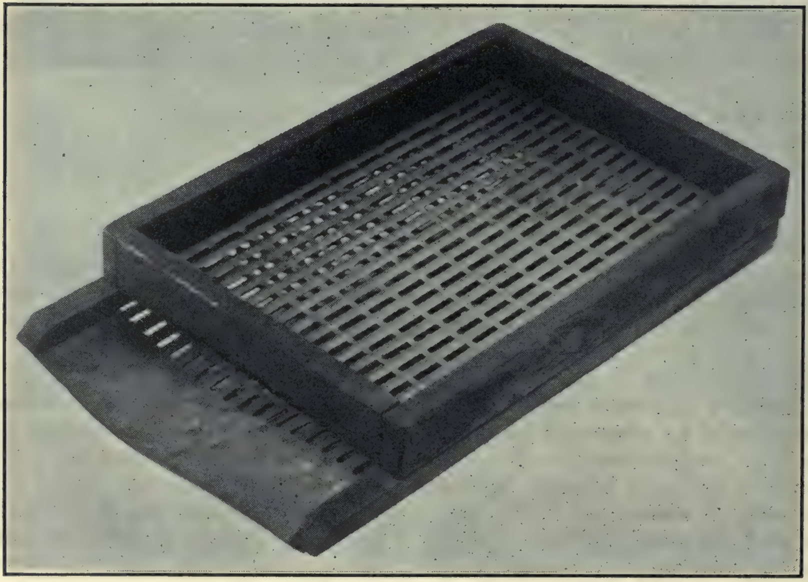

FIGURE 7.—Hand graders of the general type shown above may be used satisfactorily for small quantities of seed corn.

Each kernel lot should be carefully tested in the planter in which it is to be used before planting time and a planter plate selected (or obtained if necessary) that will drop the seed uniformly.

SEED TREATMENT

The treatment of seed corn with any of the mercury dusts manufactured for that purpose is recommended under some conditions. The primary purpose of seed treatment is to kill certain seed-borne disease-producing organisms without injuring the seed. Increases in yield from seed treatment will depend largely on the percentage of kernels infected with these parasites.

Even the best lots of seed may carry appreciable amounts of infection with the ear rot organisms, principally *Diplodia*, *Fusarium*, *Gibberella*, and *Basisporium*. Seed matured or stored under unfavorable conditions may carry appreciable amounts of *Penicillium* and other of the so-called weak parasites. The planting of seed carrying such infections may result in reduced field germination, blighting of the young plants, or reduction in the vigor of the plants that survive. The extent of such infections in seed corn, as well as the reduction in yield following the planting of such seed, depends on many factors and varies from year to year. In general, it may be said that damage caused by the seedling blight diseases appears to be of greatest importance in the central, more humid areas of the Corn Belt.

Seed treatments usually, though not always, improve stands and yields of corn in the central Corn Belt States and, in some years, in other States. Such treatments are most likely to improve low-germinating seed or that planted early or in cold, wet soil.

The following three dust treatments are available commercially from most dealers in farm supplies at the present time: New Improved Semesan, Jr.; active ingredient, ethyl mercuric phosphate. Barbak C.; active ingredients, mercuric phenyl cyanamide and cadmium oxide. Merko; active ingredient, mercury (metallic).

The names of these products are furnished merely as information, and their mention does not imply any recommendation of them.

These three dust treatments are usually applied to the seed in a mixing machine at the rate of 2 ounces a bushel. The directions printed on the containers should be followed. When treating seed, the operator should use every precaution to avoid breathing the mercury dust, which is poisonous.

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RESEEDING RANGE LANDS OF THE INTERMOUNTAIN REGION

FARMERS' BULLETIN No. 1823

U. S. DEPARTMENT OF AGRICULTURE

REVEGETATING deteriorated range lands by sowing adaptable, nutritious, and palatable grasses is vital for adequate forage production in the Intermountain region, for profitable livestock raising, and as a safeguard against flood and erosion damage. The effect of serious droughts, greatly aggravated by overstocking, has resulted in the replacement of valuable perennial grasses by annual weeds and grasses that have much less value as forage for livestock or for proper soil protection. The abandonment of unsuccessful submarginal croplands has also added greatly to the vast acreage of deteriorated but potentially productive range lands of the region in need of revegetation.

Proper guides and procedure for revegetating run-down ranges and abandoned dry farms by artificial reseeding are necessary to safeguard against costly pitfalls and to insure reasonable success.

The procedures herein outlined are based on the experiences and research to date and should prove helpful to those administering range lands and producing livestock in the region comprising Utah, Nevada, southern Idaho, and southwestern Wyoming, commonly referred to as the Intermountain region.

Washington, D. C. Issued July 1939

RESEEDING RANGE LANDS OF THE INTERMOUNTAIN REGION

By George Stewart, *senior forest ecologist*, and R. H. Walker, formerly *conservationist, Intermountain Forest and Range Experiment Station*, and Raymond Price, *senior forest ecologist, Division of Range Research, Forest Service*

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POSSIBILITIES OF RANGE RESEEDING

A GROWING CONSCIOUSNESS of decreased forage production on the western range has given rise to a definite demand for range rehabilitation. Many land-managing agencies, both State and Federal, are projecting plans to obtain the kind of range management that will provide forage on a sustained-yield basis and also provide for a plant cover adequate to prevent abnormal soil losses and to regulate stream flow. In addition to a significant decrease in grazing capacity, deteriorated foothill and mountain ranges are not only rapidly losing their highly valuable topsoil, but in some cases by encouraging floods they are endangering whole communities in the valleys below. Deteriorated range near recreation centers destroys the beauty of the landscape and contributes to unsightly and insanitary conditions. Such areas are also highly unfavorable for desirable sorts of wildlife. This waste of soil, water, and other resources, together with the imminent risk to life and property from floods, constitutes a serious indictment of past land-management policies and is a cause of grave concern for the future.

In the Intermountain region there is in all 145,000,000 acres of range land, of which about 112,000,000 acres is deteriorated to such a degree that immediate measures for rehabilitation must be taken. Forage production on these lands is normally low and uncertain; yet all of the 5,000,000 sheep and a large part of the 1,000,000 cattle in the region depend on these ranges for a major part of their feed during 6 to 12 months of the year. The greater part of the area, approximately 100,000,000 acres, will revegetate naturally under proper range management. The remaining 12,000,000 acres, which includes numerous areas of high value for watershed and other land services, and on which deterioration of the forage cover has reached a stage that is little less than disastrous, will need to be revegetated artificially.

The restoration of these key areas is of vital importance to the welfare of the grazing industry and to other interests in the region.

Of this deteriorated land about 5,000,000 acres is abandoned cropland, largely former dry farms, with good soils and potentially the most productive spring and fall range in the region. Another 6,000,000 acres in the foothills and valley edges is in the spring and fall zone, lying mostly between the cultivated farms and the lower edge of the summer range in the higher mountains. The remainder, about a million acres, consists of so-called "sore spots" on the national forests—relatively small isolated areas where livestock were formerly allowed to concentrate and where, as a result, vegetation and soil have both deteriorated; or, in some instances, bad fire scars.

Restoration of the deteriorated but still potentially good spring and fall range is most essential, since this type of range (fig. 1) is the bottleneck, so to speak, of the livestock industry in the Intermountain region. Not only must the spring and fall range bear the double burden of two seasons of grazing use, but unless it is in a sufficiently thrifty condition to be available early in the spring and to maintain a good stand of dry forage for fall grazing, the result is inevitable, costly overuse of the summer and winter ranges or expensive supplemental feeding.

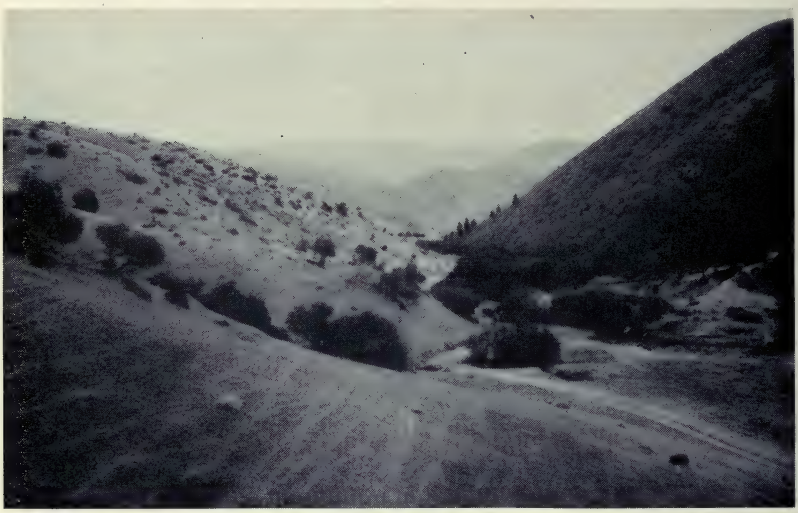
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Figure 1.—Valuable spring and fall range so deteriorated that hardly a seed plant remains of the desirable forage grasses. Artificial reseeding is essential if such areas are to be rehabilitated and furnish sufficient nutritive forage for livestock during the critical spring and fall seasons.

The sore spots on the national forests and on privately owned summer range, although smaller in aggregate area than the depleted spring and fall range in need of revegetation, are no less important (fig. 2). They are for the most part burned-over areas or meadows the forage cover of which has been depleted by past overgrazing. They are located in the high mountains, from which, once the land is denuded, floodwaters descend and are likely to cause disastrous property losses in the valleys below. Many of the costly floods in this region have been traced back to such an origin, and the evidence is equally clear that under similar conditions of slope and rainfall, where a good plant cover has been maintained, no such disastrous floods have occurred.

Is the proposal to reseed such a large area of deteriorated range a practical one? Research has shown by numerous experiments that it is, provided the natural conditions of the site are good, the vegetation introduced is adapted to the site, and proper subsequent protection and sound grazing practices are applied to the seeded area. Results of experiments on national-forest ranges as well as of actual range demonstrations of seedings by the Forest Service based on these experiments bear out this assurance. Confirmation is also given by recent experiments by the Montana, Colorado, and New Mexico Agricultural Experiment Stations, as well as by the Northern Rocky Mountain and the Southwestern Forest and Range Experiment Stations of the Forest Service. Seeding trials and demonstrations carried on by the Soil Conservation Service, the former Resettlement Administration, and other Government agencies, as well as those of private individuals, further indicate the practicability of range reseeding and have given considerable impetus to such a range-betterment program. All these tests and experiences unite in giving assurance that in the Intermountain region artificial reseeding can be reasonably sure of

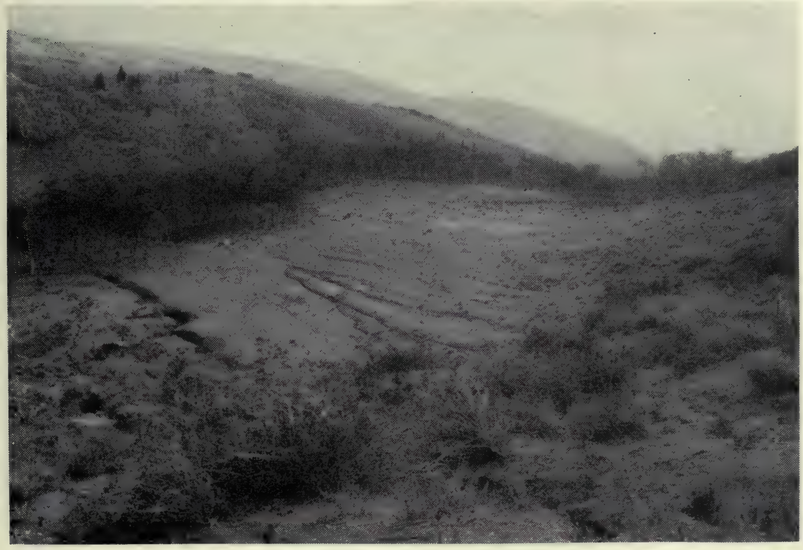
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FIGURE 2.—One of the sore spots in the head of Parrish Canyon, Utah, on which floods have originated repeatedly. This area was recently added to the Wasatch National Forest. Once a well-vegetated and choice grazing ground, this piece of range is in urgent need of reseeding to prevent floods and to check further erosion. Such a critical area justifies an expense for reseeding or transplanting far above the anticipated value of the forage it would produce, since water collecting on the present barren area may cause further floods, damaging to agricultural lands in the valley below.

success on areas having fairly heavy rainfall, not too thin a topsoil layer, and other equally favorable growing conditions, if aided by proper grazing practice.

Not all of the 12,000,000 acres in special need of rehabilitation in the Intermountain region is equally promising for artificial reseeding. About one-third of it, however, still has a fairly productive soil that will absorb precipitation water readily. This 4,000,000 acres consists largely of abandoned dry farms, mountainous and foothill range lands in both private and Federal ownership, and lower winter ranges in grazing districts that are adjacent to the national forests and to private ranges. On these lands as a whole, precipitation is at least sufficient to maintain a stand of good forage plants. Plant restoration has as good a chance here as under similarly favorable conditions on experimental areas. On such lands high hopes for range reseeding are justified, and these are the lands that should be reseeded first. Furthermore, knowledge to guide procedure on such lands has already been accumulated, whereas research in regard to the reseeding of the less favorable tracts has much yet to reveal before methods and practices can be specified in detail.

The purpose of this bulletin is to bring together present knowledge of reseeding practice in this region for the information of those engaged in reseeding operations. Effort has been made to show what procedures are considered reliable and what pitfalls must be avoided in choosing the areas on which to work, in selecting and obtaining the seed, in choosing the time for sowing and methods of getting the seed into the ground, and in the care given the newly planted lands. Directions are also included for procedure on particularly difficult sites which, because of their great watershed or other community value, are of sufficient importance to require immediate care of a more detailed and costly nature than would be justified on most wild lands. In the preparation of this bulletin, the guiding principles applying to classes of conditions have been emphasized; no attempt has been made to present precise details for individual conditions. There are two reasons for this: (1) The accumulation of information at this stage in the research program is adequate for the formulation of major principles but lacks many of the specific details which can be filled in only as investigations make headway; and (2) the extreme variety of conditions with respect to soil, slope, exposure, precipitation, temperature, and natural plant cover makes the number of individual cases almost endless. It would be impossible to include them all under anything more definite than broad guiding principles.

GUIDES IN CHOOSING AREAS FOR RESEEDING

Guiding principles in the choice of areas for reseeding are best determined from the study of type examples. Descriptions of sites and treatments where reseeding has succeeded and of those where it has failed, point to the factors contributing to success or failure. The results of this analysis, coupled with basic agronomic information known to be reliable for the region, permit the drawing of some general conclusions.

The first example is an area on Major Flat in Ephraim Canyon, in central Utah, where sowings of smooth brome,[1] mountain brome, and crested wheatgrass were successful. At this place the elevation is 7,150 feet and the average annual precipitation 12 inches. The area is typical of the higher foothill ranges of central Utah, which under favorable conditions bear a growth of big sagebrush, bluebunch wheatgrass, perennial weeds, and mountain brush (chiefly Gambel oak). The soil on this site is fertile, light gray-brown, and fine-textured, containing a fairly large percentage (4 percent) of organic matter. It is also friable and easily penetrated by moisture. The surface soil is firm yet finely granular and forms a favorable seedbed for grasses. Spring and fall precipitation is usually adequate.

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[1] A list of common and botanical names of plants mentioned in this bulletin is given on p. 25.

On this area, 6 years after reseeding experimental plots under fence, there was a marked increase in the grazing capacity as compared with that of the heavily grazed adjacent range. The grazing capacity of the plots seeded to crested wheatgrass, smooth brome, and mountain brome were, respectively, 281, 719, and 222 percent higher than that of the adjacent open range. Slender wheatgrass did about as well as crested wheatgrass (fig. 3).

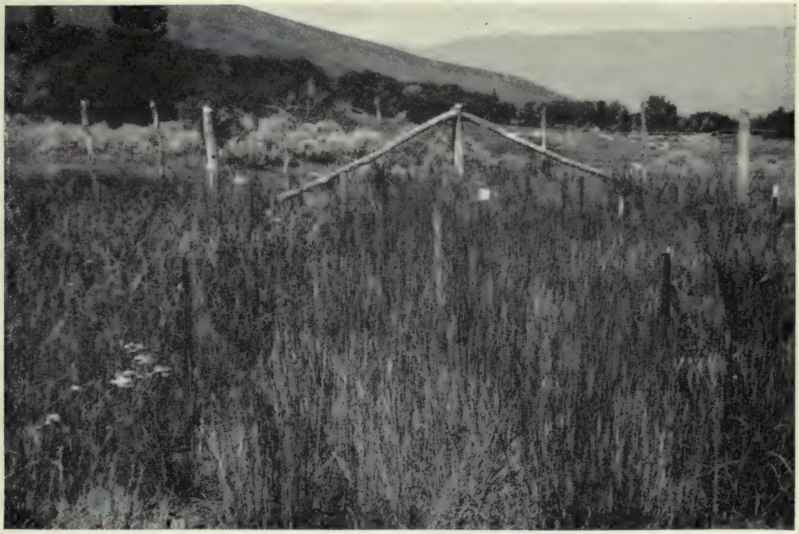
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Figure 3.—A good stand of slender wheatgrass in an experimental reseeding plot in the foothills near Major Flat, in Ephraim Canyon, Utah. The soil is a deep, fertile clay loam, high in organic matter and easily penetrated by water.

Similar results were obtained in reseeding trials with these species on two other vegetative types in Ephraim Canyon at higher elevations—7,890 and 8,000 feet—in the center of and at the upper limits of the oak-brush zone. Big sagebrush, serviceberry, mountain-mahogany, and bitterbrush grow in the openings between the more dense stands of gambel oak. Grasses such as slender wheatgrass, Letterman needlegrass, and mutton grass are native to these areas, although they have been largely replaced by annual weeds and low-value shrubs. The average annual precipitation on these areas is approximately 17 and 20 inches, a large percentage of it falling as snow during the winter months. The soil is darker in color and contains appreciably more organic matter than that on Major Flat.

Remarkable success was likewise obtained with smooth brome on a fenced area at the ranger station in Oak Creek Canyon in west-central Utah, where the elevation is 5,500 feet. The soil is deep and dark-colored and absorbs water readily. The average precipitation is about 15 inches.

Reseeding to crested wheatgrass on an abandoned plowed and fenced area of 1½ acres on the United States Sheep Experiment Station at Dubois, Idaho (elevation 5,500 feet), yielded about 400 percent more forage than on unseeded adjacent range. The soil is a firm but friable, light-brown, fertile loess silt loam of basaltic origin. It absorbs water readily. As it dries, the surface 2 to 3 inches forms a crust and becomes somewhat hard. The average annual precipitation of about 10 inches, mostly in the form of snow and early spring rains, ordinarily wets the soil to a good depth.

Some 20 to 30 similar sites in the Intermountain region have yielded fairly comparable results. They are all small in area, have moderate to good precipitation, and all have deep, well-preserved soils of naturally high productivity and moisture-supplying power. On all of them livestock grazing was under control during the time the plants were becoming established.

It must be realized that conditions which on casual examination seem favorable may not necessarily assure satisfactory results. For example, on 10 to 20 acres on Philadelphia Flat in Ephraim Canyon, Utah, at nearly 10,000 feet elevation and with approximately 29 inches of precipitation annually, mountain brome, slender wheatgrass, and Kentucky bluegrass failed to maintain effective stands after each of several attempts, even though this site in early days bore a magnificent stand of grasses. Smooth brome, however, has developed a fair stand. The explanation of the failure lies in the loss through wind and water erosion of several inches of topsoil, exposing a compact clay loam. This soil is not only low in plant nutrients but also extremely deficient in organic matter; it absorbs water slowly and becomes very hard when dry. Most of the natural vegetation is now Rydberg pentstemon, a perennial weed of very low palatability, interspersed with other weedy plants. Practically no native grass occurs, except in a small cove where the topsoil has been preserved; here there is also an almost complete cover of bluegrass, the result of seeding. On the extreme west edge of the flat a few acres of dark friable soil bear a good cover of Letterman needlegrass.

In one instance in southern Utah, several thousand pounds of seed, largely Kentucky bluegrass, sowed on sites at various elevations has failed thus far to produce satisfactory stands. This failure has resulted largely from the sowing of a species unadapted to the soil and climatic conditions. Many of the soils where the seed was sown are shallow and have lost through erosion much of the topsoil, which is the most productive and also the most effective in holding available soil moisture. This loss of soil, coupled with an extremely dry season the year the seed was sown, practically precluded the germination and establishment of the grass. Kentucky bluegrass is not well adapted to conditions of this sort, as is indicated in table 1.

Seedings of smooth brome, crested wheatgrass, slender wheatgrass, or sheep fescue were complete failures on a nongrazed area in southwestern Millard County, Utah, in 1934. The normal precipitation of this area is only 7 or 8 inches annually and the vegetation is characteristically salt-desert shrub. The season was one of extreme drought; and wind erosion was very active during the period of the test.

The results from reseeding were unsatisfactory in two other instances on the southern edge of the Boise National Forest in Idaho. In one of these instances, on Willow Creek, plots of crested wheatgrass and tall oatgrass failed almost completely. Here the soil is badly eroded, and livestock could not be kept off until the plants were well started. Again, on the Danskin drainage, tall oatgrass and velvetgrass made a good growth until livestock congregated on the plots and destroyed the young plants; though soil and moisture conditions were favorable, practically none of the plants survived.

From these examples of success and failure and from the knowledge of basic agronomic conditions, five conclusions may be drawn that will be helpful guides in choosing areas on which reseeding may normally be expected to yield satisfactory improvement in the plant cover.

(1) Range or watershed areas are much more likely to yield satisfactory plant stands from artificial reseeding when there is a moderately ample supply of moisture, or approximately 12 inches or more of annual precipitation. Occasional rains during the summer months are very helpful in the establishment and maintenance of grass seedlings through the usually dry, hot summers. Areas of low and uncertain precipitation, as for example the desert-shrub winter ranges, are so unfavorable that extensive reseeding on these ranges will not be practical until more data are gathered or more drought-resistant plants than are now available have been found or developed.

(2) A fairly deep fertile soil of medium to fine texture, well supplied with organic matter and capable of holding large quantities of available moisture, is a great assurance to success in reseeding range lands. All the marked successes with reseeding previously noted were obtained on deep, rich soils that had not suffered severely from accelerated erosion. Even under favorable moisture conditions, poor soils, as on Philadelphia Flat, prevent any appreciable improvement in the plant cover following reseeding even with aggressive grasses and the best seeding methods now known.

(3) Other good site qualities that are conducive to successful reseeding include low to medium slope with some vegetation that will aid in preventing the run-off and evaporation of an unduly large part of the precipitation. The native vegetation should not, however, be so heavy as to compete seriously with or choke the seedlings. Bald southwest exposures having steep slopes are generally unfavorable, for not only is a large portion of the precipitation lost on such slopes before it can be absorbed by the soil, but evaporation also is often excessive, leaving the soil too dry for good seed germination or for maintenance of seedlings.

(4) The native plant cover that formerly occupied the area is frequently a useful guide as to what degree of success may be expected. Remnants of palatable shrubs, such as mountain snowberry, serviceberry, and bitterbrush, and of palatable grasses, especially slender wheatgrass, mountain brome, native bluegrasses, needlegrasses, or fescues, indicate that site conditions were once and probably still are favorable to the better forage grasses. The presence of only tough

unpalatable plants or annuals should in the main be regarded as a warning that it may be difficult for the better plants to take hold and grow, though in some cases a favorable site has suffered a loss of all the better plants without the site itself having deteriorated.

(5) Of vital importance to success with reseeding is the elimination of livestock grazing for the first season after seeding and until after seed maturity the second season. This topic is discussed with some detail in a later section, Care of Newly Seeded or Planted Areas.

Certain critical areas closely related to the welfare of dependent communities demand immediate measures, regardless of unfavorable site conditions, in an effort to control soil erosion and regulate stream flow. The special measures required on these areas to assure the growth of grass are discussed later in the section, Revegetating Critical Areas.

GUIDES IN DETERMINING WHAT SEED TO SOW

The more palatable perennial grasses are in general the most effective in aiding absorption of water, holding soil against erosion, and producing abundant feed for livestock. The choice of forage plants for range reseeding depends largely, however, upon their adaptability to the conditions of the site in question. Table 1 supplies helpful aid in selecting forages with the greatest chance of survival under any given set of conditions.

It is needful also to take into account the type of range with which any given seeding area is identified. In the Intermountain region there are three general types: (1) The high mountain range, which is grazed only during the summer months; (2) the lower foothill and valley edges, grazed generally for a month or two in the spring and again in the fall; and (3) the desert valleys and ridges, which are usually grazed during the late fall, winter, and early spring months. Owing to the generally low rainfall and the relatively hot and dry summers, reseeding trials on the desert ranges so far have been rather unsuccessful. Extensive reseeding on the deserts, therefore, is not recommended until such a time as research provides more information concerning appropriate plants and methods to use. The following discussion therefore applies to mountain, foothill, and sagebrush valley ranges.

IN THE HIGH MOUNTAINS

The high mountain ranges, which extend from elevations of 6,000 to 7,500 feet up to 10,000 feet or higher, have a relatively short growing season and usually receive a larger amount of precipitation than do the foothill and desert ranges. Much of the precipitation comes as winter snow and a smaller proportion as summer rain, leaving the soil rather dry during a part of the warm growing period. The grasses best suited to high mountains are those not readily injured by severe cold or periodic drought (fig. 4).

Grasses that have done well in reseeding trials on high mountain ranges are mountain brome, smooth brome, slender wheatgrass, and bluestem and needlegrasses (fig. 5). Mountain brome has grown over a wide range of altitude, with greatest success in the aspen-fir zone. The wheatgrasses and smooth brome also have done well from the lower edges of the mountain ranges to the higher elevations. In addition to these grasses, Kentucky bluegrass and timothy grow

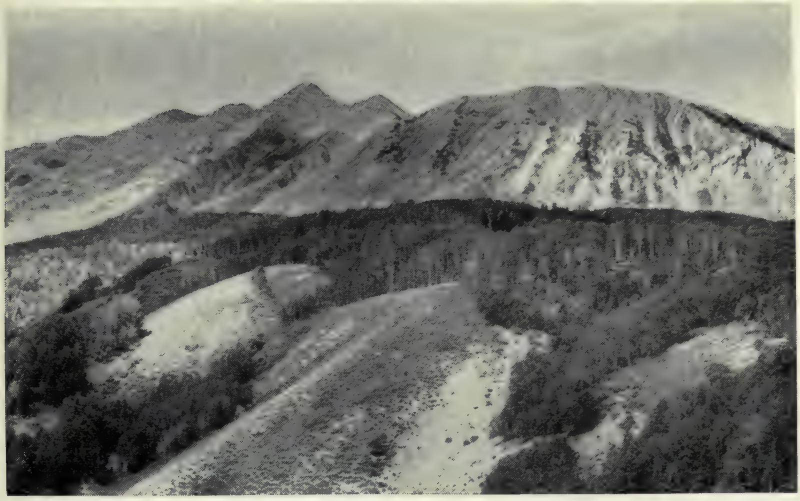
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FIGURE 4.—The high mountain ranges are used chiefly for summer grazing. Many bare spots on these ranges are in need of reseeding as a means of achieving erosion control and watershed protection as well as to maintain forage production. Owing to the higher precipitation here than on the lower foothill spring and fall ranges, a wider variety of grasses are suitable for reseeding.

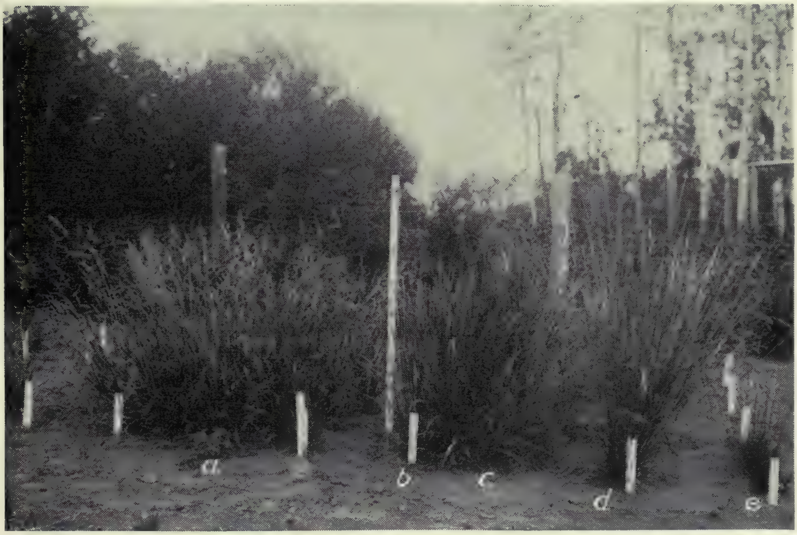

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FIGURE 5.—A group of the five desirable perennial forage grasses. The bromegrasses, mountain brome (*a*) and smooth brome (*c*), are highly palatable and bear many basal leaves. Slender wheatgrass (*b*) has a slender, upright growth and is well adapted to most high mountain ranges in the intermountain region. Needlegrasses (*d*, *e*), with basal leaves and upright flower stalks, are well adapted for reseeding.

well in mountain meadows, where the soil remains fairly moist throughout the growing period. Orchard grass has succeeded in shady places where the soil is not subject to severe drying.

TABLE 1.—*Adaptation, growth, and forage qualities, and seeding information regard region (including*

Name	Climatic adaptation	Soil adaptation	Site adaptation
Slender wheatgrass.	A native of western range lands. Very hardy and drought-resistant, but not equal to crested wheatgrass and smooth brome in these respects.	Best adapted to well-drained soils of medium to light texture (silt loams, loams, and sandy loams). Tolerant of alkali, and will grow on fairly poor soils.	Will grow and produce viable seed from the more favorable foothills to the higher mountain ranges, Thrives in dry mountain meadows. Has done well in reseeding trials on mountain ranges in Utah.
Bluestem	Native western range grass. Hardy and highly resistant to drought.	Prefers fine-textured soils, loams, silt loams, and clays which contain only a small portion of gravel and coarse rock fragments. Highly resistant to alkali.	Thrives on well-drained bottom lands, open plains, benchlands, and hillsides of the lower mountain and foothill ranges principally in the sagebrush-wheatgrass zone.
Bluebunch wheatgrass.	Native bunchgrass of intermountain region and Columbia River Basin. Extremely drought-resistant and endures much cold.	Grows on well-drained light sandy loam soils and is often the chief grass on scablands, benchlands, and on gritty, poorly disintegrated soils of low water content.	Adapted to sagebrush zone, on open dry hills, mountain slopes, and plains and will thrive on sites too dry and poor for smooth brome.
Crested wheatgrass.	Native of cold dry plains of Siberia. Extremely resistant to drought and cold, surpassing slender wheat grass and smooth brome.	Does well on productive, well-drained soils of almost any texture ranging from light sandy loam to heavy clay.	Especially adapted to foothill and lower mountain ranges.
Smooth brome	Adapted to regions of rather low rainfall and moderate summer temperature. Endures cold and drought remarkably well.	Prefers rich loams and clay loams, but will succeed on sandy soils.	Grows well from lower foothill or sagebrush zone to higher mountain ranges. Does best in aspen zone with 15 to 20 inches precipitation. Equals or surpasses crested wheatgrass on higher ranges.
Mountain brome.	Well adapted to the cooler, moister mountain areas of the West. Not as drought-resistant as smooth brome.	Grows best in fairly moist loam soils, but will grow in moderately dry clay and sandy loams. Will grow in rather poor, depleted soil.	Grows with more vigor and produces better stands in the aspen zone and on the higher ranges.
Tall oatgrass	Does not endure severe cold, but will withstand considerable summer heat. Fairly drought-resistant but not so much so as smooth brome.	Thrives on well-drained, loose deep loams and calcareous soils but succeeds also on sandy and gravelly soils.	Will probably grow best on moist sites. Will not endure shade.
Meadow fescue	Adaptation similar to timothy. Thrives in cool, humid climate but is not suited to hot, dry climate.	Prefers rich, moist, or even wet soils. Does not succeed well in sandy land.	Probably best adapted to mountain meadows where soil is moist throughout the growing season.
Sheep fescue	Similar to Idaho fescue which is native to northern Nevada, Utah, and the Snake River plains of southern Idaho. Highly drought-resistant.	Will grow on poor and sandy or gravelly soils. Does not require as moist conditions as meadow fescue.	Adapted to dry foothills, plains, and mountainsides. Will grow on drier sites than many other grasses.

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[1] Acknowledgment is made to Alvin C. Hull, Jr., junior range examiner, Intermountain Forest and

ing forage grasses and alfalfa for artificial reseeding on ranges of the Intermountain abandoned farm lands)[1]

Time and rate of seeding	Palatability and grazing capacity	Character of growth
Best sown in the fall but may be sown in midsummer on high mountain ranges or in the spring where moisture conditions are favorable—5 to 12 pounds per acre when sown alone.	Highly esteemed for palatability and nutritive value. Relished by cattle and horses throughout the year. Sheep are not so fond of the mature leafage but take the seed heads readily. Somewhat susceptible to trampling injury.	Deep-rooted, thick-tufted perennial bunchgrass. Makes stocky, leafy growth 18 to 40 inches high. Free from awns or beards. Grows slower, matures later, and yields less than crested wheatgrass. Produces good seed crop.
Best sown in the fall but may be sown in the spring where moisture conditions are favorable—8 to 15 pounds per acre.	Highly nutritious and palatable. Grazed and relished by all classes of stock. Cures well on ground and makes good winter feed. Yields somewhat less than crested wheatgrass.	Rigid, upright perennial spreading vigorously by underground rootstocks. Forms an open sod. Seed crop usually scant and seed low in viability. Becomes established slowly.
Same as for slender wheatgrass.	Young plants relished by all stock. Mature leafage not highly palatable to sheep. Will not stand heavy grazing but yields well under judicious management.	Slender bluish-stemmed perennial bunchgrass 1 to 3 feet high. Has long stout divergent or twisted awn. Poor seed producer; seed not often available on market.
Best sown in fall but may be sown in early spring where moisture conditions are favorable—3 to 8 pounds per acre sufficient when well distributed. Thin stands in beginning soon improve.	Produces an abundance of highly palatable and nutritious forage, relished by all classes of stock. Makes good pasture and yields well under seemingly adverse conditions.	Hardy, long-lived, drought-resistant perennial bunchgrass. Makes rapid and early growth in spring, is dormant during hot, dry periods of summer, and resumes growth in fall. Produces viable seed in abundance. Very aggressive when once established.
Sow 8 to 15 pounds per acre in late fall preferably, but may be sown in early spring where moisture conditions are favorable.	Grows early in the spring, produces abundance of highly palatable forage, and makes good pasture relished by all stock.	Hardy long-lived perennial, produces many underground rootstocks, forming a dense sod under favorable conditions. Grows 2 to 4 feet high and produces numerous basal leaves. Has done well in reseeding tests.
Best sown in late fall but may be sown in midsummer on high mountain ranges or in early spring where moisture conditions are favorable—10 to 15 pounds per acre.	Grazed closely by all classes of stock when young. Becomes somewhat unpalatable to sheep at maturity. Large seed heads relished by all stock.	Perennial without rootstocks. Grows in thinner stands than common brome, but yields abundance of forage 3 to 4 feet high, produces good seed crop, and spreads without difficulty. Seed usually not on market.
Best sown in late fall or early spring where moisture conditions are favorable—8 to 15 pounds per acre.	Nutritious and palatable when stock become accustomed to it.	Long-lived, deep-rooted, hardy perennial bunchgrass. Green from early spring to late fall. Seed often low in viability.
Best sown late in fall but may be sown in midsummer on high mountain ranges or in very early spring—8 to 15 pounds per acre when sown alone.	Is good pasture grass on moist soils. Very palatable and nutritious.	A tufted, deep-rooted perennial without rootstocks. Makes a fairly good sod under favorable conditions. Best sown in mixture with timothy or Kentucky bluegrass.
Same as for crested wheatgrass.	Nutritious and highly palatable, especially to sheep. Withstands close grazing.	Small perennial bunchgrass with abundant deep strong roots. Forms dense tufts 3 to 6 inches in diameter with numerous erect bluish-green leaves 2 to 4 inches long.

Range Experiment Station, who verified a large part of the information given in this table.

TABLE 1.—*Adaptation, growth, and forage qualities, and seeding information regard region (including abandoned*

Name	Climatic adaptation	Soil adaptation	Site adaptation
Kentucky bluegrass.	Grows best in a moderately moist, cool climate. Resistant to cold but languishes in hot dry weather.	Prefers rich, well-drained loams or clay loams. On poor soil it is never abundant. Not drought-resistant.	Thrives in moist mountain meadows. Will not grow on dry sites or in shady places.
Canada bluegrass.	Adaptation generally the same as Kentucky bluegrass, but is more resistant to summer heat and to drought.	Will grow on poorer soils than Kentucky bluegrass, succeeding on gravels and on thin soils over rock or clay.	Will grow on drier sites than Kentucky bluegrass, and is not adapted to moist or wet areas. Does not succeed in shade.
Bulbous bluegrass.	Grows best in moderate climate and at medium elevation. More drought-resistant than Kentucky bluegrass.	Grows on variety of soils from coarse to fine texture (sandy loams to clays).	Probably best adapted to lower foothill ranges used for early spring grazing. Requires moist soils.
Perennial ryegrass, Italian ryegrass.	Primarily adapted to moist regions with mild winter climate. Continue to grow at low temperatures but will not withstand severe winter cold. Do not withstand hot, dry weather.	Grow best on rich soils of medium to fine texture. Do not do well on sandy soils.	Thrive on moist, well-drained sites.
Timothy	Northern grass, thrives well in cool, humid climate, but is not suited to hot, dry climate.	Will succeed on wide range of soils but grows best on fine textured soils (clay loams and silt loams).	Best adapted to moist mountain meadows and sites where soil is fairly moist throughout growing season.
Orchard grass	Does not stand cold as well as timothy but is somewhat more drought-resistant. May be injured by late spring frosts.	Best adapted to clays or clay loams. Prefers a moderate amount of moisture and will grow in wet soils.	Succeeds well in shady places, with moderate soil moisture.
Sudan grass	Requires a warm climate for best development; upper altitudinal limit in Intermountain region is 5,000 to 6,000 feet. Dought-resistant.	Best adapted to well-drained rich loams but will grow on wide variety of soils. Does not tolerate alkali.	Best adapted to the more favorable southwest exposures in direct sunshine. Does poorly on cold wet sites.
Rye	Adapted to cool climates and regions of cold winters; hardier than wheat.	Responds to good soils but will produce a good crop on poor soils. May be grown on almost all soil types but especially adapted to soils of medium to coarse texture (loams and sandy loams).	Will grow on foothill and high mountain ranges. Best adapted to sites similar to those used for dry farming.
Alfalfa	Grows best in semiarid climate. May be injured by severe cold. Young plants are often destroyed by heaving of the soil caused by alternate freezing and thawing.	A deep, fertile, well-drained soil permits best development. Mature plants tolerate considerable alkali but will not grow in waterlogged soils.	Best suited to the more favorable sites on foothill ranges and valley edges. May prove valuable on abandoned dry farms.

ing forage grasses and alfalfa for artificial reseeding on ranges of the Intermountain farm lands)—Continued

Time and rate of seeding	Palatability and grazing capacity	Character of growth
Best sown in fall or early spring at rate of 5 to 10 pounds per acre.	Very highly palatable and nutritious, relished by all classes of stock. Grows early in spring and late in fall.	Hardy, long-lived perennial spreading by short underground rootstocks. Becomes established slowly and does not form sod until second or third year.
Best sown late in fall or very early spring—5 to 10 pounds per acre when sown alone.	Highly palatable and relished by all stock. Withstands moderately close grazing.	A hardy perennial similar to Kentucky bluegrass. Produces abundant rootstocks and forms a tough sod under favorable conditions.
Early fall seeding preferable—5 to 10 pounds per acre.	Highly palatable and nutritious. Forage yield medium to low.	Perennial, reproducing by bulbs at base of stem and by bulbils produced in place of seed. Grows very early in spring, dries down in hot summer, and begins growth again in the fall.
Preferably sown in early spring at rate of 8 to 15 pounds per acre. Less seed may be sown in mixtures.	Very palatable and nutritious, and produce a large quantity of forage for 1 or 2 years.	Short-lived, rapidly growing perennials, living only 2 or 3 years on poor lands but longer under favorable conditions.
Best sown in fall or early spring in mixture with other grasses at rate of 4 or 5 pounds per acre—8 to 12 pounds when sown alone.	Produces abundance of nutritious herbage. Relished by all stock.	Hardy perennial producing a tall and leafy luxuriant growth on moist soils. Becomes established quickly and produces well the second year. Does not withstand close grazing.
Best sown in late fall or early spring—5 to 10 pounds per acre.	Palatability medium to high. Makes excellent early pasture where adapted.	Long-lived perennial, forming distinct bunches with dense circular tufts. Spring growth is more abundant and earlier than timothy. Also grows late in the fall. Best sown in mixtures.
Must be sown in spring, preferably after late frosts when soil has become warm—10 to 20 pounds per acre.	Produces an abundance of forage, yielding more than most grasses where it will grow. Nutritious and eagerly eaten by all stock.	Strictly an annual. Grows rapidly to a height of 3 to 6 feet. Produces numerous broad leaves. Tillers freely. Will furnish forage while perennial grasses are getting started.
Preferably late summer and fall but may be sown in the spring—about 20 pounds per acre with other grasses or 30 to 60 pounds when sown alone.	Highly palatable and nutritious. Makes good fall and spring pasture.	An annual very similar to wheat. Grows rapidly, will furnish forage while perennial grasses are getting started.
Best sown in early spring or summer at 5 to 10 pounds per acre. Inoculation of seed before planting is advisable.	Very highly palatable and nutritious. Produces abundance of forage, but will not stand continuous close grazing.	A deep-rooted perennial of the legume family. Grows from 1 to 2 feet high, producing a very desirable, fine, leafy forage.

ON LOWER SLOPES

On the lower foothills and valley edges, which correspond to the sagebrush-wheatgrass type, the more favorable mesas or benchlands in need of reseeding have been broken up in many places and used principally for dry farming. Where dry farming has proved unprofitable and the lands have been left idle, they should be returned to range. On such abandoned lands reseeding to grasses of high forage quality will usually produce satisfactory stands. The elevation of the foothills, usually varies from 4,500 to 5,000 feet, but the desert mountain ranges run up to 6,000 or 7,500 feet. Average annual precipitation in most of the foothill zone is 10 to 15 inches, with extremes of 8 and 20 inches. Usually most of the precipitation is in the form of snow, only occasional showers coming during the growing season. Because the soil moisture is usually low during the summer months, only the most drought-resistant or early growing grasses are adapted to these ranges.

On these lands the wheatgrasses have given good results in many places. Crested wheatgrass seems to be particularly well adapted, especially in the northern part of the region; it has done well on range lands of the Snake River plains of southern Idaho, and on abandoned dry-farm lands of northern Utah and southern Idaho. It has also grown well on the foothill and lower mountain ranges. Bluestem grows well on the heavier soils and on the moister sites. Bluebunch wheatgrass has succeeded fairly well in artificial-reseeding trials in protected locations on the coarse-textured and rather porous soils of these ranges. Slender wheatgrass and smooth brome are adapted to the more favorable sites and to the higher slopes where there is somewhat more precipitation. Rye and alfalfa have thrived on areas similar to those cultivated for dry farming.

Since range soils vary so widely, it is essential that full consideration be given to the adaptability of the various grasses to the soils on which they are to be sown, as indicated in table 1. It is as unwise to sow grasses on soils to which they are not adapted as to sow them on ranges having unfavorable climatic conditions. In determining the grass or grasses best suited for sowing on a given site, it is good practice to be guided by the plant species that grow there naturally and are well-adapted to the particular soil and climatic conditions. One or more of these, or a species having similar growth requirements, may well be chosen for reseeding. Even grasses not native to the area, if they are closely related or similar to the native grasses in their growth requirements, may often be well-adapted for reseeding. Smooth brome, for example, is not native to the western range country but grows well on mountainous areas to which mountain brome and slender wheatgrass are native. Likewise, crested wheatgrass has proved well adapted to the lower foothills and valley edges where the bluestem and bluebunch wheatgrass thrive.

HOW TO OBTAIN SEED

Seed dealers, especially the larger ones, have in recent years stocked a rather wide variety of commercial grass seed of the sorts usually used for reseeding. After poor seed years or during periods of great demand, the species most favored are likely to be high-priced or even difficult to obtain at any price. In such cases, and for some ranges seeds of adapted native species are necessary, and these can be obtained only by field collection. Where sufficient labor is available, the seed of such grasses as the bromes and wheatgrasses may be collected by hand without special difficulty. Comb seed strippers have been used successfully for collecting the seed of mountain brome and slender wheatgrass in the Wasatch Mountains in Utah. In other localities machine seed strippers, drawn by horse or motor, have been successful. Many seeds are stripped off by hand. Also, clean and ripe seed has been easily and quickly collected by shaking the ripened grass seed stalks into sacks without removing the stalks from the plants.

If possible, commercial seeds should be not more than one or two seed generations removed from stock grown under arid conditions and in a locality where the winters are at least as severe as those of the region in which the seeds are to be sown; otherwise the young seedlings that start growth may soon die because they are unable to withstand the growing conditions of the site. Reliable dealers furnish dependable information concerning the species, the purity, and the germination of the seed they sell. It pays to use seed of high purity and high germination.

WHEN TO SOW

The best time to sow grass seed in the Intermountain region is determined by seasonal and moisture conditions. Since a dependable moisture supply is all-important for effective germination of grass seed and for the establishment of grass plants, it is safer to sow the seed just before the rainy period for the locality is most likely to occur.

On this basis, July and August are favorable months for sowing in the high mountains, which normally receive several summer and autumn rains. Also favorable in the mountain and the upper foothill zones are late autumn, just before winter sets in, and very early spring, just before or immediately after the snow disappears.

In the lower foothills and valley edges—especially on abandoned farm land where a reasonably good seedbed occurs naturally or has been provided by tillage—the most favorable time for sowing grass seed is the same as that for dry-farm wheat. In most localities this is between the latter part of August and the middle of October. It is hard to specify the best time more precisely since it necessarily varies within this period for each major locality and for different seasons. Where the autumn precipitation is very low it may be unwise to sow as early as this, since if germination is started and then stopped by a protracted dry period the sprouts are likely to die. In this case late fall sowing is advisable in order that the seed may be ready to germinate at the earliest possible date in the spring.

In the foothill and valley zones, spring sowing with a drill is best done as early as the soil will permit the use of machinery. When no drill is to be used, the best time is as soon as possible after the melting of the snow.

SEEDBED PREPARATION AND COVERING THE SEED

On a large part of the range lands in need of reseeding—possibly 50 to 60 percent of the area—seedbed preparation prior to planting is not feasible, owing either to the steep or rough topography or to the expense involved. This, however, does not preclude the possibility of success in reseeding. Seed sown on good soils late in the autumn may fall into the numerous small fissures and cracks resulting from the alternate freezing and thawing of the surface soil. Here the seed may be covered by further disturbance of the soil brought about by frost or surface water and germinate the following spring as the snow melts and the soil becomes warm. Superficially this seems the easiest and cheapest method of seeding; but a considerable element of chance is involved, and success is much less certain than on those areas where steps can be taken to prepare the seedbed or cover the seed, or both.

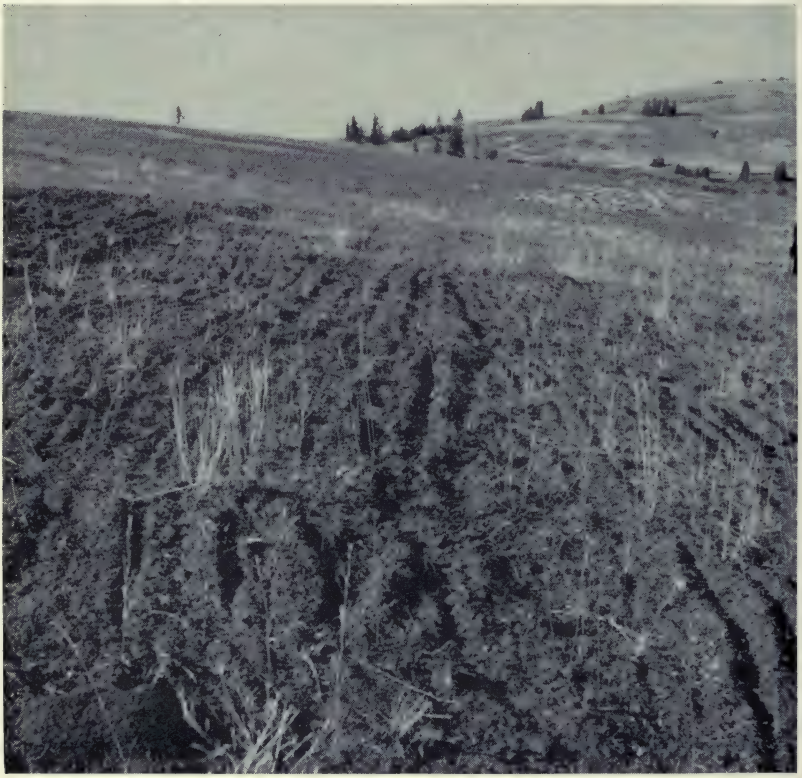
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FIGURE 6.—On lands where the soil is easily tillable a good seedbed can be prepared with a spike-tooth harrow. Seed sown broadcast before harrowing will be covered sufficiently to aid germination and seedling development.

The best seedbed for grasses is one having a fairly deep and firm soil beneath 1 or 2 inches of loose and fine-textured topsoil. Here seed may be covered more readily, and quick germination and early development of the seedlings will be encouraged by more favorable moisture conditions. Although in most instances the expense involved is a prohibitive item, preparation of seedbeds should be undertaken wherever possible, to provide a favorable start for the young plants.

Ordinarily on compact soils bearing heavy stands of weeds, disking will remove the weeds sufficiently to permit the use of a grain drill and also put the soil in good condition for seeding. Loose soils may be sufficiently worked with a spike-tooth harrow (fig. 6). Disking or harrowing has been found especially suitable in brush areas having soils favorable for high forage yields. Small open areas interspersed with clumps of tall brush, such as serviceberry or oak can be thus prepared satisfactorily at reasonable cost. In most cases where the weed growth is small and the soils not particularly compact, drilling among annual weeds is equally satisfactory. On abandoned cultivated land from which the better native vegetation has been removed and where weeds—usually Russian-thistle—have grown up, the seedbed may be prepared by disking or harrowing, or even by plowing.

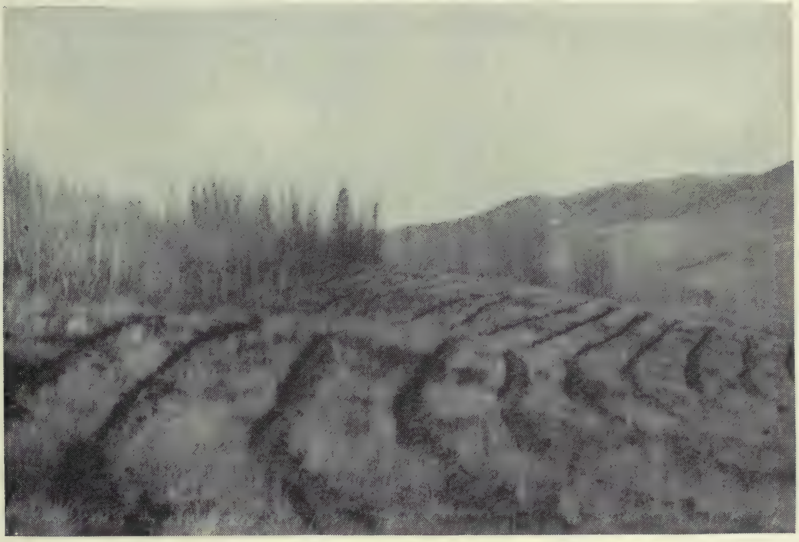
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FIGURE 7.—Contour furrows spaced 2 to 4 feet apart at right angles with the slope afford an effective seedbed at comparatively low cost. After the seed is broadcast over the freshly-plowed furrows, it may be covered effectively with a brush drag or spike-tooth harrow.

Plowing is too expensive except in particularly favorable spots where forage production great enough for hay is expected or on critical areas where a stand of vegetation is so imperative as to justify higher costs. But, on the other hand, in heavy stands of downy chess or sagebrush and on lands with a compact surface soil, plowed furrows several feet apart may constitute the only successful low-cost method (fig. 7).

It is particularly important to cover spring- or summer-sown seed. Where seedbed preparation is impossible or too costly, it may be feasible to cover the seed by going over the area with a harrow or brush drag or by driving sheep over it to trample the seed into the soil (fig. 8). Each of these methods has been found effective. If the soil has a tendency to puddle and bake, however, the trampling of wet soil by sheep may cause serious packing and result in failure. On slopes where it is imperative to establish grass stands as quickly as possible and where other methods are not feasible, it may be desirable to cover the seed with hand rakes. The time and expense involved make this method justifiable only on extremely critical slopes.

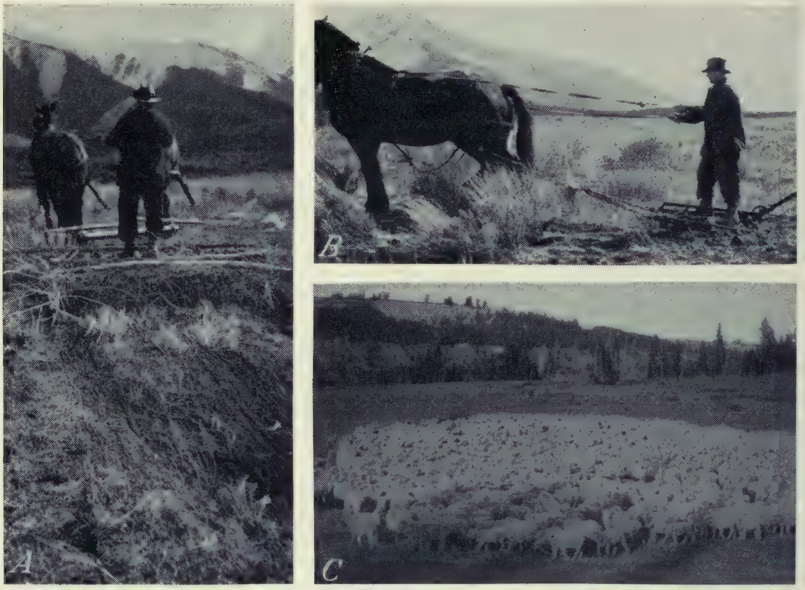

FIGURE 8.—Three methods of covering seed sown without seedbed preparation: *A*, Use of a brush drag; *B*, harrowing; *C*, driving sheep over the sown land.

DISTRIBUTING THE SEED

One-half or one-third the amount of seed used on tilled land ordinarily suffices for range land, except on especially productive soils or where needs other than forage warrant extra costs. From 5 to 10 pounds to the acre of the seed of large-seeded plants such as bromes, bluestem, and tall oatgrass is sufficient, if fairly even distribution can be obtained in sowing; and 3 to 6 pounds of that of small-seeded plants such as slender wheatgrass, and sheep fescue. When a drill is used, part of the spouts may be stopped to reduce the quantity of seed sown. Where the topography is uniform enough and woody plants or rocks do not prevent, a drill insures a fairly even distribution and a more effective covering of the seeds (fig. 9, *B*). The use of a narrow machine permits successful drilling on unusually steep slopes if precautions are taken to keep the drill from tipping over.

Hand seeders (fig. 9, *A*) require less skill in getting the seed evenly scattered, but they cannot handle large or fluffy seeds. An experienced man can obtain fairly even distribution by hand broadcasting, and this method is applicable to all types of seed; but hand sowing usually requires more seed for a given area.

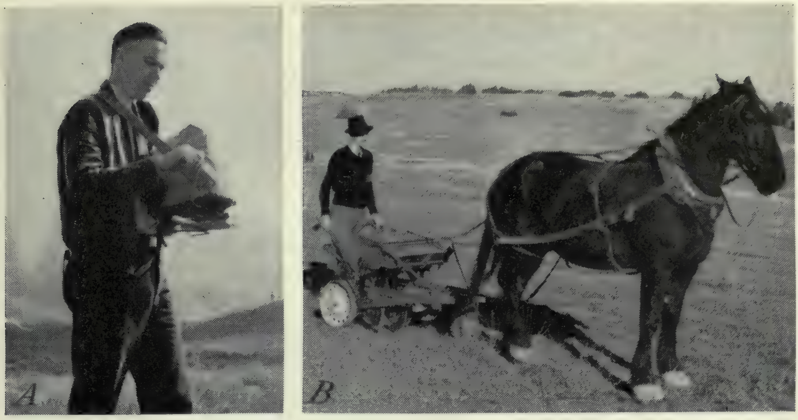

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FIGURE 9.—Some range land and most abandoned cultivated land can be reseeded most effectively and economically by broadcasting or drilling the seed: *A*, For small, smooth seeds the hand seeder is practicable and requires less skill than the drill in getting the seed evenly scattered, but it is not suitable for large or fluffy seeds; *B*, a small drill is easily managed on comparatively steep slopes and on areas broken by clumps of brush or gullies.

REVEGETATING CRITICAL AREAS

Where the welfare of dependent communities demands immediate measures to control soil erosion and to regulate stream flow, more intensive methods of revegetation than would generally be justified may be adopted. Such areas occur mostly on steep slopes where a large proportion of the rainfall runs off rapidly before it has opportunity to be absorbed by the soil. Generally a large proportion of the more productive topsoil has been washed away, leaving exposed a subsoil deficient in organic matter and available plant nutrients and hence incapable of absorbing or retaining water as effectively as the topsoils. It has a tendency to become exceedingly dry and to bake hard, affording a very poor seedbed and little nourishment for any plants that do become established. The most valuable forage plants too often either fail to start growth or die soon after. Such areas may require special measures for revegetation.

The high frequency of unpredictable drought and the serious injury it does to seedling plants often make two seedings necessary before the stand is really established, especially on the poorer soils of critical areas, where even the best methods of seedbed preparation are none too effective. Special care in getting the seed into a favorable place for germination and quick growth of the young seedlings will aid greatly in speeding up the revegetation process.

The steep slopes may have to be terraced to stop erosion while the grass plants are getting established. This has been tried with much success on the critical watershed lands of Davis County, Utah. In addition to stopping erosion, the terracing of such slopes provides a better seedbed and holds needed run-off water, thus aiding materially in the establishment of the new plants (fig. 10). Even when raw subsoil is exposed in the bottom of the terrace ditch, the surface soil washing into the trench soon provides a good seedbed.

Many raw subsoils are low in productivity because of deficiency in available plant nutrients. Agricultural experience has shown that in many instances it would be more economical to supply the necessary plant nutrients by applying some fertilizer than to sow seed repeatedly with little hope of adequate returns. The high values of watersheds for supplying irrigation water for farm lands and a domestic water supply for cities and towns may justify the expense of this treatment for many critical areas.

Barnyard manure is not generally available for fertilizing such lands, but commercial fertilizers may sometimes be used to advantage. The plant nutrients most likely to be deficient are nitrogen and phosphorous. Common nitrogen fertilizers are ammonium sulphate and sodium nitrate, but there are many commercial brands of fertilizers on the market that contain this plant nutrient. The treble superphosphate commonly sold in the West is especially adapted for use on range lands on account of its concentrated form, which reduces the unit cost of transportation. Such fertilizers may usually be purchased from seed dealers. These fertilizers may be spread, either alone or in combination, at the rate of about 50 to 100 pounds per acre at the time the soil is being prepared for seeding. The fertilizer may be applied on the surface without cultivation although best results will be obtained if it is worked into the surface soil by disking, harrowing, raking, or any other means that may be found practicable.

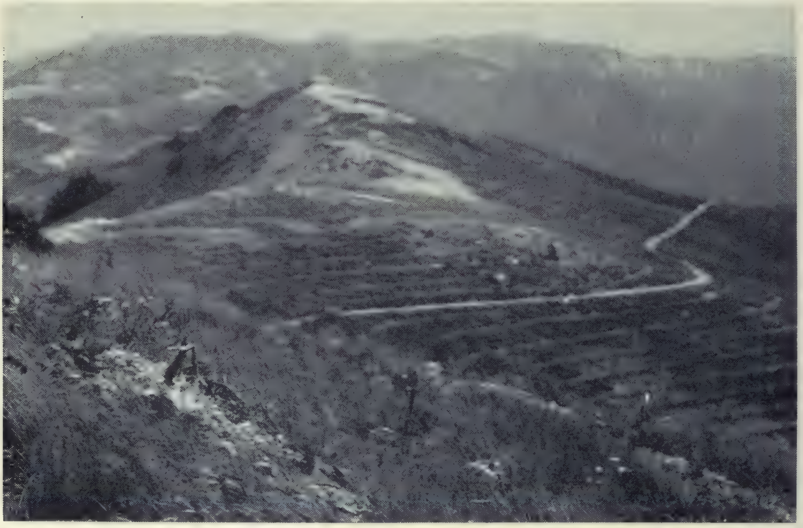

Figure 10.—A slope in Davis County, Utah, terraced before seeding. Where the values at stake warrant such expense, terracing, by providing a favorable seedbed and collecting moisture, aids materially in getting a good grass stand.

Special consideration should be given to the selection of the species of grass to plant on the critical areas. Although it would be desirable to have a good stand of long-lived perennial grass, particularly one of the better sod-forming grasses such as smooth brome or bluestem, it may be necessary to sow small grain or a quick-growing grass with these—even an annual or one that is neither especially long-lived nor a good soil binder—in order to help protect the area against erosion while the more permanent grasses are getting established. Plants suited for this purpose are rye, winter wheat, oats, barley, and Sudan grass in localities where the growing season is long and hot.

Rye establishes itself readily on moist soils, grows quickly, and covers the ground long before many of the more permanent grasses become established. Rye also will do fairly well on most poor soils. Although it is not permanent, it grows rapidly and will temporarily hold the soil against erosion. It also aids in the preparation of the seedbed for the better forage grasses that may be sown at the same time or later and thereby assists in their establishment. In addition to protecting critical areas against erosion and improving the soil for the establishment of other permanent grasses, these plants, on areas where grazing cannot be entirely avoided, will also produce considerable forage while the better permanent grasses are getting started.

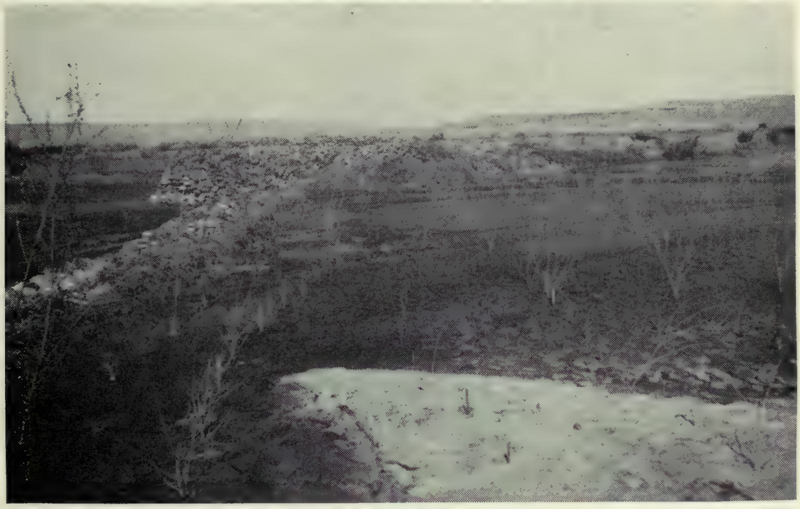
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FIGURE 11.—A transplanting of cottonwood to control erosion above a flood-control dam.

It may even be expedient to transplant vigorously growing native or introduced grasses or other plants on critical areas to hasten revegetation, especially on bad erosion areas where shrubs and trees may also be planted. Considerable transplanting of this sort has been done recently on critical watersheds, largely through C. C. C. camps supervised by the Soil Conservation Service, Forest Service, and other agencies (fig. 11). Many native shrubs may be used for this purpose, and in most cases they are better adapted to the prevailing climatic and soil conditions than are imported species.

CARE OF NEWLY SEEDED OR PLANTED AREAS

New seedings and plantings of perennial grasses require protection for 1 or 2 years against livestock grazing and, so far as possible, against other unfavorable influences. The young plants need time enough to establish a root system and to produce some top growth before they are grazed. Even plants that are sturdy when established may be fatally injured by trampling, by being pulled up or so loosened that they dry excessively, or by removal of the top growth before food reserves are stored in the roots and root crowns. Not much is lost by excluding grazing, for livestock gets little feed from the spindling growth produced by most grasses the first season. On critical areas, which will include practically all transplanted areas and many of those reseeded, several seasons of protection, or at least of very light grazing, will be most in keeping with the ends sought.

Grazing control is essential to the success of the reseeding project. The area grazed, the time of grazing, and the completeness of utilization by sheep may be controlled by careful herding; but fencing is surer. Since cattle are not ordinarily attended by a herder, they require fencing, except where the topography, supplemented by some drift fencing in the gaps, affords control or where the necessary control may be attained by systematic salting. Most critical areas, therefore, should be well fenced, and reseeded areas that are not critically important for watershed protection should be fenced or controlled by range riders. All the noteworthy successes cited earlier were achieved on land where livestock grazing was under control. Lack of livestock control brought many failures, even where other conditions were favorable.

Frequently, on low ranges, any open space in the plant cover develops at once a heavy stand of Russian-thistle, and any on the foothill ranges, one of downy chess. At first, either of these annual plants may retard the establishment of the new perennial plants by shading and removal of the available moisture. In the end, however, the accumulation of litter from the annuals builds up the organic matter and favors the increase of perennials. On the most critically important areas, removal of the weeds may be warranted; in all other cases the threat of erosion from removing the weedy cover is dangerous and the cost prohibitive.

A heavy infestation of rodents will require the use of some measure for control to save new plantings. Where big game is especially abundant, high fences for protection against deer may need to be provided.

COSTS INVOLVED

COST OF SEED

The major item involved in artificial revegetation is the cost of the seed, which naturally varies with the quantity required and the cost per pound. Smooth brome seed costs normally about 15 cents a pound. A minimum rate of 5 to 10 pounds to the acre to obtain a satisfactory stand makes the initial cost amount to $0.75 to $1.50 an acre for seed alone. Crested wheatgrass in 1938 and for the next few years will probably cost from 20 to 40 cents a pound, but because of the small size of the seed, the acre requirement is only about 3 to 8 pounds, making an acre cost of $0.60 to $3.20. Bluestem at a normal price of 10 to 15 cents a pound costs from $0.60 to $1.50 for 6 to 10 pounds an acre. Owing to unfavorable climatic conditions that may arise, failures may occur and two seedings may be required before satisfactory stands are established. Hence it may be necessary to double these figures for a conservative estimate of costs except under normal conditions. The price of seed depends largely on the supply available. Recently the demand for the most favored species, such as crested wheatgrass, has exceeded the supply, resulting in increased prices where the seed is obtainable. A summary of the various items of cost is given in table 2.

TABLE 2.—*Estimates of cost*[1] *per acre of preparing seedbed; of protection against grazing, including removal of stock for 1½ years; of seeding; and of seed for artificially reseeding range lands in the intermountain region*

Method of preparing seedbed and sowing	Seedbed preparation on—			Protection[2] (exclusion of grazing)	Seeding	Seed
	Experiment plots	C. C. C. initial sowings (average)	Areas of 5 or more acres			
Seed sown broadcast on contour furrows and covered with brush drag	$2–$5	$2–$5	$1–$3	$0.03–$0.10	[3] $1	$0.60–$3.00
Seed sown broadcast on plowed contour furrows with no further treatment	2–5	--------	1–3	.03– .10	[3] 0.50	.60– 3.00
Seed sown on harrowed ground and covered with harrow	--------	1–3	1–2	.03– .10	.1 –1.50	.60– 3.00
Seed sown on harrowed ground and trampled with sheep or cattle	--------	1–3	0.75–1.25	.03– .10	.30– .75	.60– 3.00
Seed sown broadcast on unprepared ground and trampled in with sheep	--------	--------	--------	.03– .10	.30– .80	.60– 3.00
Seed sown broadcast on unprepared ground with no further treatment	--------	--------	--------	.03– .10	.30– .65	.60– 3.00
Seed drilled with team and grain drill	--------	--------	.30–.50	.03– .10	[4] 1–1.50	.50– 2.00

[1] Costs vary so widely with the economic conditions, the slope, relative smoothness, and presence or absence of brush on the range, fluctuating seed prices, accessibility, and the stockman's facilities for doing the work that the costs here presented, while actually incurred in some cases, are approximations within certain limits rather than exact figures.

[2] Includes fencing, the cost of which varies with the method—ranging from a few rods of drift fence to an entire enclosure.

[3] Rough approximation.

[4] Drilling the entire area on abandoned cultivated land without any previous preparation; and on steep slopes having neither brush nor large rocks, drilling in strips about one-third to one-half the area, leaving the unseeded strips to fill in by natural reseeding from plants that become established on the drilled strips.

LABOR COSTS

Labor costs depend on the method of sowing. Intensive methods of soil preparation and seed covering materially increase the total costs, whereas broadcast sowing followed by trampling-in the seed with livestock holds the cost to a minimum. Where labor includes soil preparation, sowing, and covering the seed, costs vary widely, as shown in table 2 for small-scale experimental plantings, initial C. C. C. projects, and areas of 5 acres or more seeded with a grain drill. Seeding on extensive areas naturally reduces the cost per acre.

COST OF PROTECTION

The cost of protecting new sowings from grazing until the plants become established varies with each site. The cost depends on the length of time protection is needed and on the local demand for pasturage. Ordinarily, adjustments in grazing can be made to relieve small areas of seeded range without material reductions in livestock. Where there is a fair amount of native forage, the range may support moderate grazing during the latter part of the second year after seeding without injury to the new seedlings. Where protection of young plantings from grazing cannot be accomplished by adjustments in livestock on the range, the cost of full protection must be reckoned.

HIGH LIGHTS OF RESEEDING

Except for a few critical areas demanding immediate revegetation regardless of cost, range reseeding in the Intermountain region can well be confined for the present to the 4,000,000 acres having deeper soils and more favorable moisture conditions. Through research, methods may meanwhile be developed for reseeding the less favorable sites.

Some of the reseeding and transplanting will probably be undertaken with public funds on a project basis. Such work may be either on public land or on private land having high values for, or constituting serious hazards to, the public welfare. The major effort, however, will probably be made by stockmen on their own land, for the purpose of increasing the forage production.

The most promising plants for reseeding in high mountains are mountain and smooth bromes, slender wheatgrass, and bluestem. Only in wet or moist meadows have Kentucky bluegrass and timothy done well. In the foothills and upper valley edges, slender and bluebunch wheatgrasses have done better than other grasses on rough land, and bluestem does well on moist, fine-textured soils; crested wheatgrass has succeeded, especially on abandoned dry farms in the northern part of the region; rye and alfalfa have shown promise on the better soils of some abandoned cultivated land. On the desert areas no great success has as yet been obtained.

Early spring or preferably late autumn is the best time for reseeding, except on high mountains where summer rains make July or August the most favorable seeding time.

Sowing on abandoned dry farms and moderately level range not covered with brush is best done with a grain drill; on rough or brush-covered range, with a broadcasting machine or by hand in coutour furrows or after harrowing. In the latter cases, seed should be covered as effectively as possible with a harrow or brush drag or by trampling in with sheep.

New plantings need full protection against grazing for the first season and until late in the second season, when they may be subjected to very light grazing.

Plowing makes the labor cost so high that it is seldom justifiable. Contour furrowing is much cheaper and may be warranted where the nature of the ground favors its use. Where forage is the principal form of return, lower labor costs are sought by drilling the seed without previous soil preparation, or by broadcasting and covering the seed as inexpensively as possible. Seed costs may be decreased by thin sowing or seeding in strips. Even on good soils, however, costs are sometimes increased by the necessity for a second seeding, owing to the failure of the first as a result of untimely drought.

On critical watersheds, extra costs in labor and fertilizer may be warranted in order to speed up revegetation. In some cases transplanting is needed.

Reasonable success from reseeding may be expected at moderate cost when (1) areas having average-or-better soil and moisture conditions are chosen, (2) only a thin stand of vegetation is present,

(3) seed of species that have proved successful is sown, (4) the seed is so sown as to be covered with soil, and (5) grazing on the area is adequately controlled.

COMMON AND BOTANICAL NAMES OF SPECIES DISCUSSED

Alfalfa	*Medicago sativa.*
Big sagebrush	*Artemisia tridentata.*
Bitterbrush	*Purshia tridentata.*
Bluebunch wheatgrass	*Agropyron spicatum.*
Blue pentstemon	*Pentstemon glaber.*
Bluestem	*Agropyron smithii.*
Bulbous bluegrass	*Poa bulbosa.*
Crested wheatgrass	*Agropyron cristatum.*
Downy chess	*Bromus tectorum.*
Gambel oak	*Quercus gambelii.*
Kentucky bluegrass	*Poa pratensis.*
Letterman needlegrass	*Stipa lettermani.*
Meadow fescue	*Festuca elatior.*
Mountain brome ("California brome;" "big brome").	*Bromus carinatus* (*syns. B. marginatus; B. polyanthus*).
Mountain mahogany	*Cercocarpus montanus.*
Muttongrass	*Poa fendleriana.*
Needlegrasses	*Stipa* spp.
Orchard grass	*Dactylis glomerata.*
Russian-thistle	*Salsola pestifer.*
Rye	*Secale cereale.*
Ryegrasses	*Lolium* spp.
Serviceberries	*Amelanchier* spp.
Sheep fescue	*Festuca ovina.*
Slender wheatgrass	*Agropyron pauciflorum.*
Smooth brome	*Bromus inermis.*
Snowberry, mountain	*Symphoricarpos oreophilus.*
Sudan grass	*Sorghum vulgare* var. *sudanense.*
Tall oatgrass	*Arrhenatherum elatius.*
Timothy	*Phleum pratense.*
Velvet grass	*Holcus lanatus.*
Wild-ryes	*Elymus* spp.

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Depleted Range Reseeded To Smooth B

The BLACK HILLS BEETLE

A SERIOUS ENEMY OF ROCKY MOUNTAIN PINES

FARMERS' BULLETIN No.1824
U.S. DEPARTMENT OF AGRICULTURE

THE PERIODIC WIDESPREAD EPIDEMICS OF the Black Hills beetle have been responsible for the destruction of more merchantable pine timber in the Rocky Mountain region than has any other agency.

This tiny beetle kills healthy, vigorous pines of practically all ages and of all species that occur within its range. It kills trees by attacking the trunks and thus introducing blue-staining fungi which cut off water conduction to the leaves, and by destroying the soft inner bark through which they get their nourishment.

When everything is favorable for the developing broods of this insect it increases rapidly from endemic to epidemic status and, unless unfavorable climatic conditions quickly reduce the outbreak, artificial control becomes necessary. The Black Hills beetle requires only 1 year for development, and it should be remembered it is too late to treat trees after the foliage has turned red. The beetles and new broods will be found in pines whose foliage has not begun to turn.

This bulletin describes the insect and its work, its seasonal history and habits, and the methods that have been employed to prevent and suppress outbreaks.

Washington, D. C. **Issued July 1939**

THE BLACK HILLS BEETLE, A SERIOUS ENEMY OF ROCKY MOUNTAIN PINES

By J. A. Beal, *entomologist, Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine*

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HISTORY AND EXTENT OF DAMAGE

THE BLACK HILLS BEETLE (*Dendroctonus ponderosae* Hopk.) is one of the most aggressive and destructive of bark beetles and is undoubtedly the most serious enemy of pines throughout the central Rocky Mountain region. During outbreaks this insect attacks vigorous, healthy trees, and frequently, as a result of its destructive work, extensive stands of pine timber are practically wiped out.

The first major outbreak on which observations were made occurred in the Black Hills of South Dakota from 1895 to 1908, inclusive, and it was here that the beetle acquired its name. During this epidemic between 1 and 2 billion board feet of ponderosa pine timber was killed. On the Kaibab National Forest in northern Arizona, during the years from 1917 to 1925, inclusive, this beetle killed in excess of 300,000,000 board feet of timber. An outbreak on the Roosevelt National Forest in northern Colorado, occurring between 1923 and 1930, killed an estimated total of 100,000 trees but was successfully brought under control in 1930. A serious outbreak on the Montezuma and Uncompahgre National Forests in southwestern Colorado during 1933 to 1936 was brought under control in 1936. Some 20,000 ponderosa pines were treated during this operation, but this number represents only a part of the loss, for many of the trees killed early in the outbreak were not counted. From about 1932 to the present time a very aggressive outbreak has been in progress on Elk Mountain in southeastern Wyoming, in stands of limber pine and lodgepole pine. Here the loss has averaged about 60,000 trees each year on an area of 15 sections. During the last few years many smaller aggressive outbreaks have been controlled, and others are still being fought on a number of Colorado and Utah forests. From the earliest observations to the present time a long list of outbreaks of varying intensity and destructiveness have been recorded throughout the range of the Black Hills beetle. Prompt control measures applied to small incipient infestations in recent years have undoubtedly prevented a number of serious epidemics.

The Black Hills beetle occurs in the pine-forested areas of southeastern Montana, western South Dakota, the eastern half of Wyoming, and through Colorado, Utah, New Mexico, and Arizona. It attacks ponderosa, limber, whitebark, lodgepole, piñon, Mexican white and bristlecone pines, and occasionally Engelmann and blue spruces. It seldom produces broods in spruce, however, and these trees need not be treated for this particular beetle. Of these many hosts, ponderosa pine is the preferred one, with limber, whitebark, and lodgepole pines also ranking high. Where other pines occur either in mixture with or close to these, they too are likely to be attacked. The beetle prefers trees 6 inches or more in diameter, and only occasionally during epidemics will it attack smaller trees. During epidemics it also shows a slight preference for the more vigorous, rapidly growing trees.

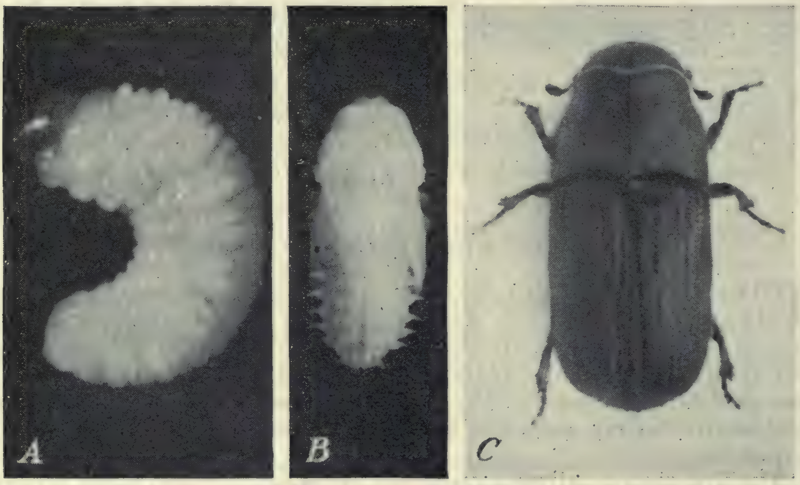

FIGURE 1.—The Black Hills beetle: *A*, Larva, × 8; *B*, pupa, × 6; *C*, adult, × 8. (Photographs by N. D. Wygant.)

When the Black Hills beetle is not numerous it breeds in weakened trees or those injured by lightning or in some other way. The beetles are often attracted to places where pines have been cut, trimmed, or pruned during the summer months, or to other locations where a strong pine odor is noticeable. Because of this, when the beetles are numerous, the trimming or otherwise injuring of but a single pine tree in the middle of or late in the summer, at about the time the beetles are in flight, may result in the loss of a number of pines in the immediate vicinity.

If conditions are favorable, the beetles increase very rapidly, and the brood from a single tree may, upon emerging, be sufficient to infest an additional three or four trees. Under these conditions small centers of infestation increase rapidly in number and size, coalescing to form larger groups and causing extensive losses. These epidemics continue until terminated either through natural factors or artificial control methods.

CHARACTER OF WORK

Damage to living trees is caused by the adult beetles and their larvae or grubs (fig. 1). The beetles bore through the outer bark and construct long, nearly straight, vertical egg galleries in the soft inner bark, slightly grooving the wood (figs. 2 and 3). They also carry in certain blue-staining fungi which rapidly permeate the sapwood. Each gallery usually has a characteristic hook at the lower end where the beetle entered the tree. These egg galleries are about three-sixteenths of an inch in width and from 1 to 3 feet long and are packed solidly with boring dust. The young grubs also mine the inner bark but extend their feeding galleries or larval mines more or less horizontally, at right angles to the egg gallery. Fully grown

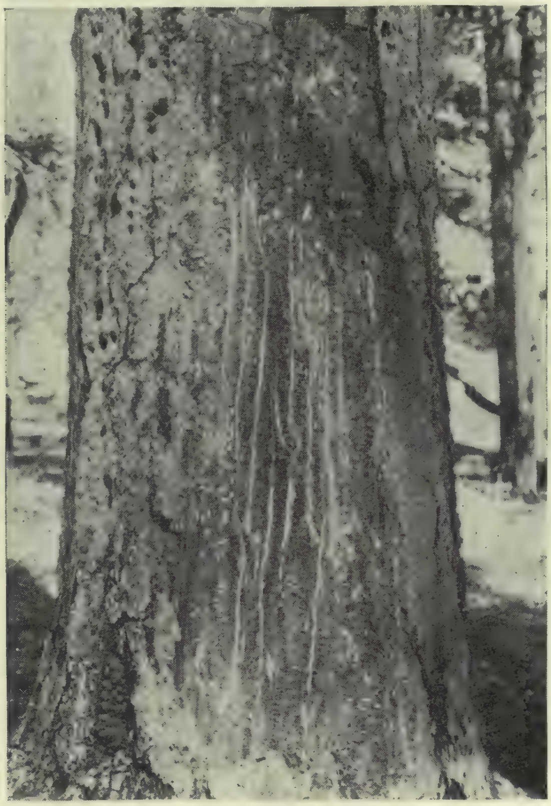

FIGURE 2.—Long, straight galleries made by adults of the Black Hills beetle, shown on wood of infested pine after the removal of the bark. Note characteristic hook at the point of entrance and horizontal larval mines.

larvae (fig. 4) construct pupal cells at the ends of the larval mines and there transform to pupae and adults. The young adult beetles usually burrow through the intervening bark between these pupal cells and congregate in a common cavity thus formed. They emerge through small round holes made in the bark, several beetles often emerging from a single hole (fig. 5).

As a result of the numerous galleries constructed in the cambium region beneath the bark and the development of the blue stains in the sapwood, the movement of water from the roots to the leaves is cut off, and the tree is girdled and killed. A large number of beetles are required to kill a healthy tree, and as many as a thousand or more adults may attack a tree of large size. Where only a few beetles attack, the flow of pitch at the points of entrance is usually sufficient to "pitch out" or overcome the beetles, and the tree is not killed. Consequently trees with only a few large pitch masses on the bark and no completed egg galleries under the bark should not be treated in control work.

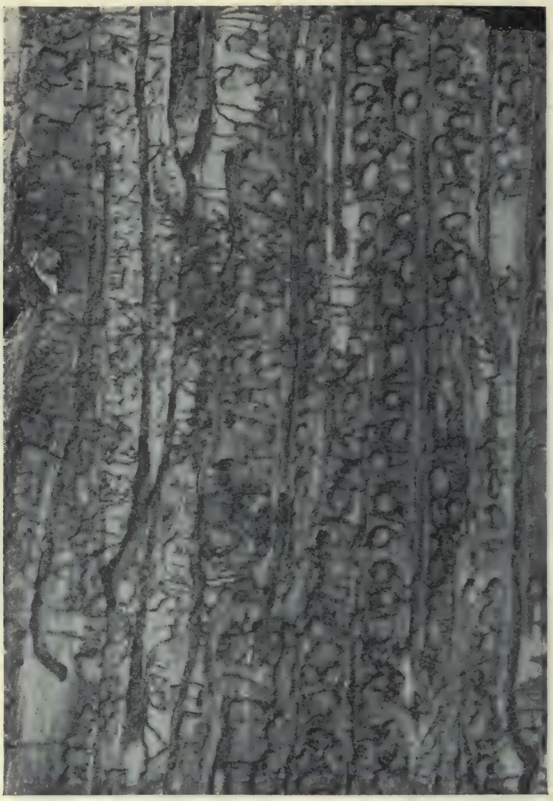

FIGURE 3.—Straight galleries made by adults of the Black Hills beetle in the soft inner bark of pine. Note characteristic hook at the lower end of the galleries (where beetle entered the tree), larval mines, and oval pupal cells along some galleries. Slightly reduced.

EVIDENCE OF BEETLE ATTACK

Trees attacked by the Black Hills beetle can be recognized by the small masses of pitch (referred to as pitch tubes) which form on the bark at the mouth of entrance holes (fig. 6), or by the presence of boring dust around the base of the tree and in bark crevices. By closely examining the pitch tubes the point of attack may be found—a tiny circular hole in the bark. Removal of the bark above one of these holes will usually reveal a pair of adult beetles at work at the upper end of their vertical gallery. If the attack is a month or more old, the mines of the young grubs can also be seen extending horizontally from the parent egg gallery. Trees attacked at the normal time in August usually do not fade until the following spring; consequently the only means of detecting infested trees during the fall and winter are the numerous small pitch tubes on the bark, the red boring dust at the base, and the vertical galleries,

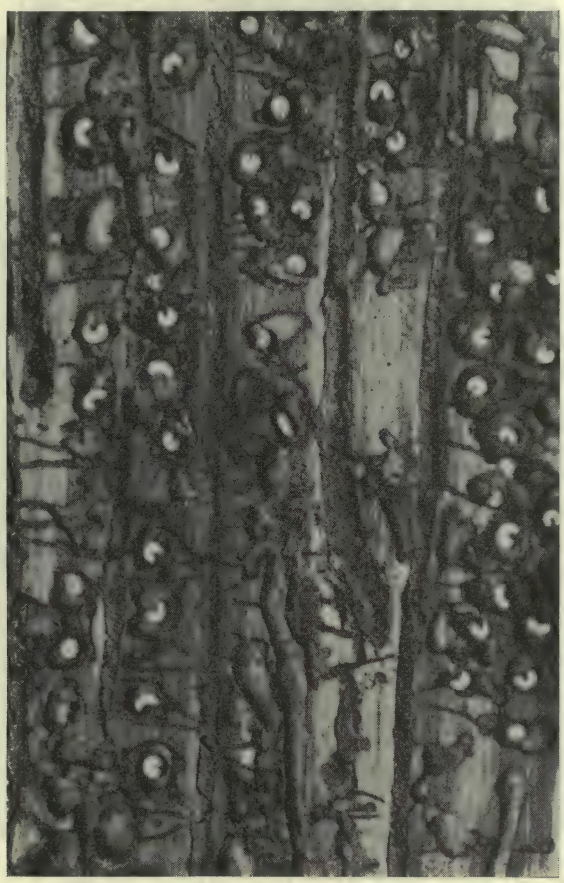

FIGURE 4.—Fully grown larvae of the Black Hills beetle in pupal cells of inner bark of pine. Slightly reduced. (Photograph by N. D. Wygant.)

tightly packed with frass, under the bark. A blue-stain fungus, which is associated with the beetle in the trees, is carried in by the beetles and spreads rapidly through the sapwood (fig. 7). Heavily blue-stained sapwood is a certain indication that the tree has been killed.

Late in the spring and early in the summer the discoloration of foliage is the best method of locating pine trees attacked by this beetle the previous summer. Usually by May of the year following the attack some of the infested trees begin to lose the natural dark-green color of their foliage and turn lighter, becoming a pale green. With warmer weather, the foliage turns a yellowish green, followed by a light-yellow or straw color, and finally a reddish brown. The foliage of different infested trees does not change color at the same time, nor is fading necessarily uniform on an individual tree. Usually one or two trees in an infested group will show discoloration first, followed by a gradual color change over the entire group.

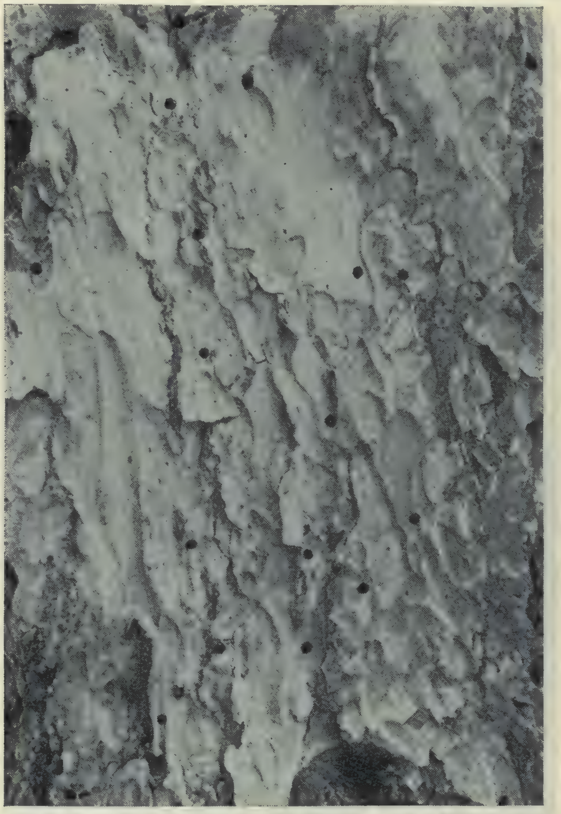

Figure 5.—Outside of bark of pine tree, showing exit holes made by emerging Black Hills beetles. Because many newly formed beetles often emerge from a single hole, these holes are not necessarily numerous. About half natural size.

The presence of "red-tops," trees having sorrel or brick-red foliage (fig. 8, *A*), usually indicates beetle infestation in the forest. After midsummer, however, these trees ordinarily contain only secondary, associated, and parasitic insects, having already been abandoned by the Black Hills beetle, which requires fresh phloem, or the inner bark of living trees, for development of its broods. The second year after attack the needles begin to fall, and heavily infested areas (figs. 8, *B;* and 9) have a grayish devastated appearance.

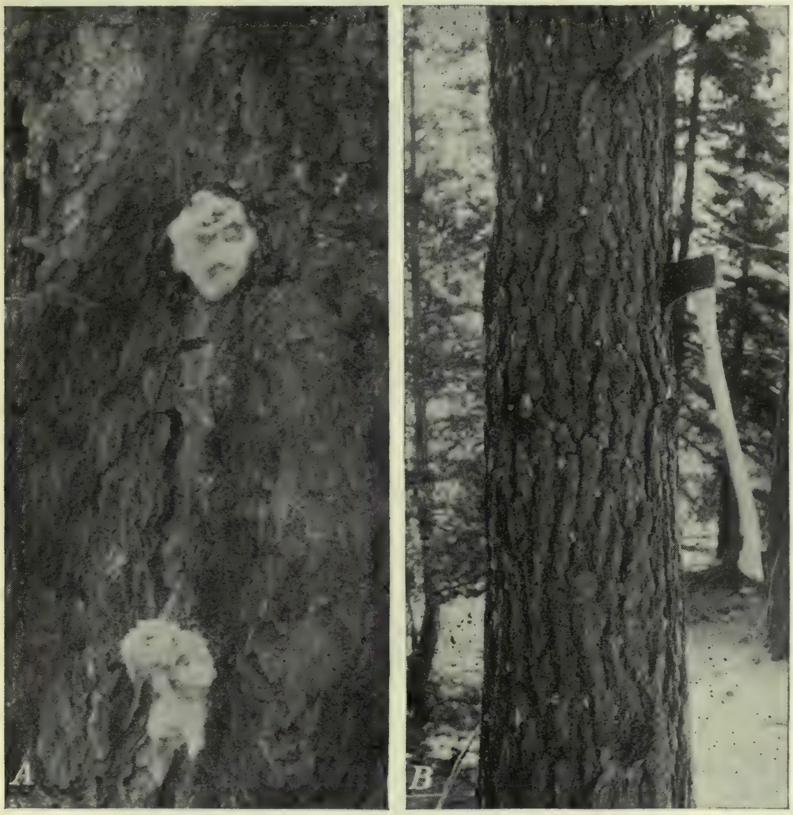

FIGURE 6.—Pitch tubes made by the Black Hills beetle: *A*, About half natural size; *B*, general appearance of pitch tubes along the trunk.

DESCRIPTION OF THE BEETLE

The Black Hills beetle passes through four distinct stages during its life history. These are the egg, the larva, the pupa, and the adult. The adults are small, rather stout, cylindrical beetles, ranging in length from two-tenths to three-tenths of an inch (fig. 1, *C*). When immature they are yellowish to dark brown, but they become black when fully mature. The eggs are small, oval, and pearly white. The larvae (fig. 1, *A*) are white, fat, legless grubs with small brown heads; at maturity they are about the size of the beetles.

The pupae (fig. 1, *B*) are also white and represent the transformation stage between larvae and adults. The appendages found on the adults can be recognized on the pupae.

SEASONAL HISTORY AND HABITS

Most of the life of this insect is spent beneath the bark of the pines in which it works. Only green trees or those with fresh, moist inner bark are attacked by the beetles, and the resulting broods usually require 1 year for development. The beetles emerge and fly chiefly during August. At this time all the faded trees are abandoned, and new, live ones are attacked.

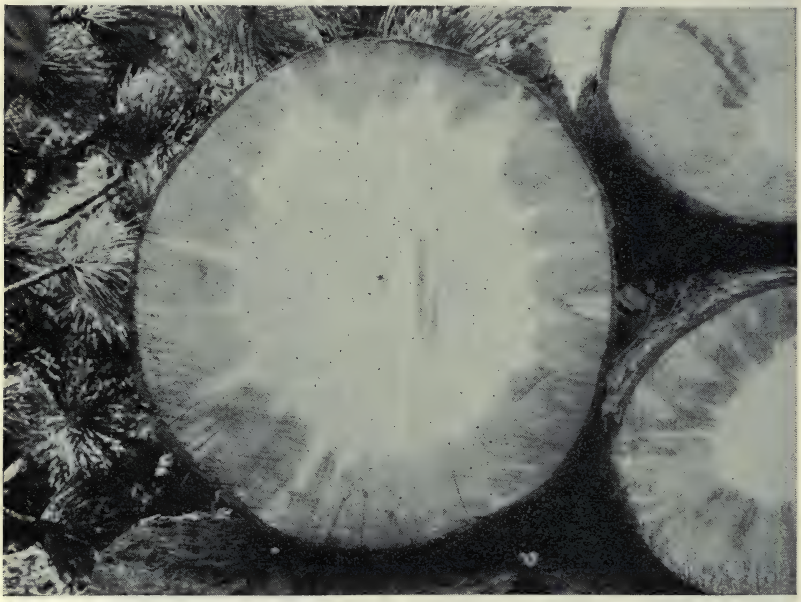

FIGURE 7.—Cross section of a pine tree killed by the Black Hills beetle, showing the associated blue stain extending to the heartwood.

Eggs are laid in niches along the sides of the egg gallery as it is being constructed late in the summer. The eggs hatch in about 10 days, and most of the larvae are half grown before winter. The larvae resume feeding in the spring. During the latter half of May the most advanced larvae begin transforming to pupae, and during the first half of June some of these change to the adult stage. The beetles, however, do not leave the infested, fading trees until most of the brood has matured, or until the middle of summer.

The flight usually starts late in July and continues during August. During this period the beetles fly to nearby green trees and immediately attack them. Dead trees are never attacked, and trees under 6 inches in diameter are seldom infested except during severe epidemics. If the flight is heavy, conditions that develop within a tree after it is attacked may attract a large number of beetles to the

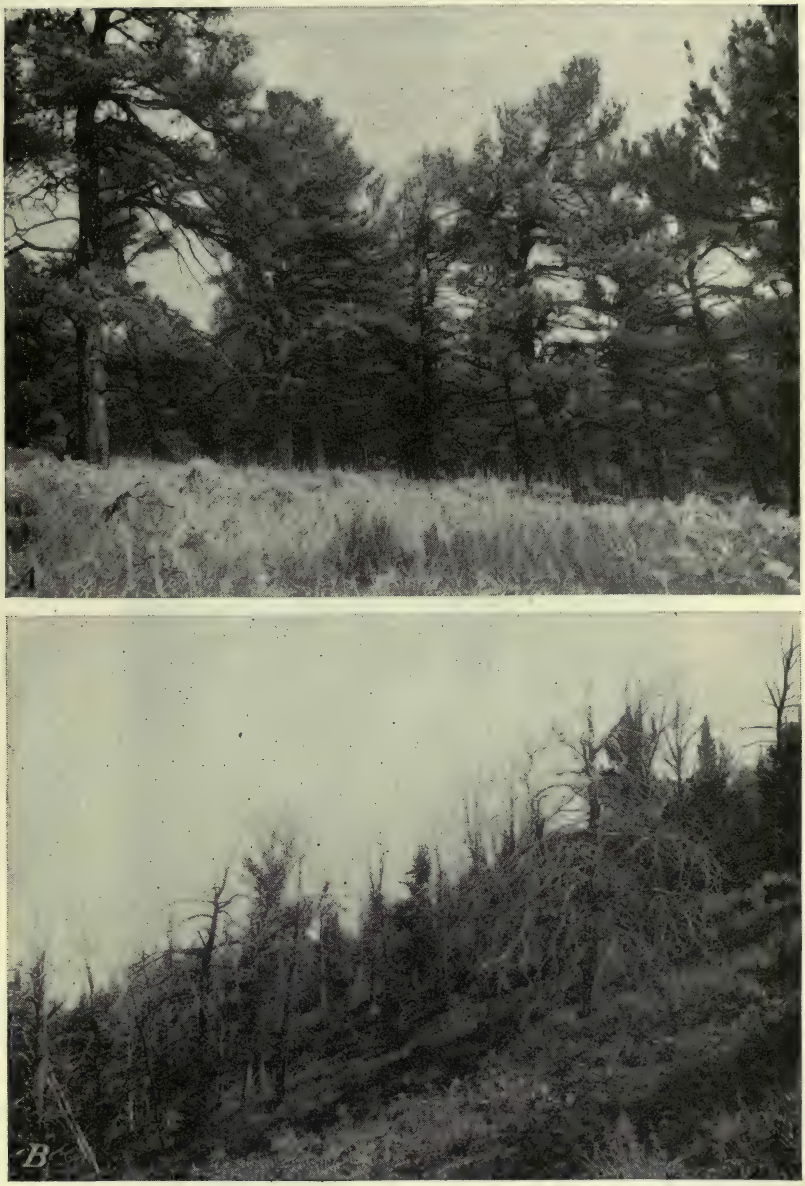

FIGURE 8. Groups of limber pines killed by the Black Hills beetle: *A*, The spring after the attack—the light foilage indicates the fading of the needles; *B*, 2 to 3 years after the attack the foilage has entirely disappeared.

spot and result in the killing of a group of trees. Although a complete generation is usually produced in 1 year, at elevations of between 9,000 and 10,000 feet in the northern limits of the beetle's range a small percentage of the brood sometimes requires 2 years for complete development.

BARK BEETLES LIKELY TO BE MISTAKEN FOR THE BLACK HILLS BEETLE

Several other bark beetles are often associated with the Black Hills beetle, but only a few of those most likely to be confused with this serious enemy of Rocky Mountain pines will be mentioned here.

THE SOUTHWESTERN PINE BEETLE

The southwestern pine beetle (*Dendroctonus barberi* Hopk.) is similar in form to the Black Hills beetle but is smaller, being only one-eighth to three-sixteenths of an inch long. It occurs throughout most of the southern range of the Black Hills beetle. It can be distinguished from this insect by the characteristic **S**-shaped and winding galleries of the adult (fig. 10). The larval mines are rarely visible on the inner surface of the bark but extend into the outer bark, where the larvae transform to pupae and adults. Because of this habit merely peeling the infested trunks will not de-

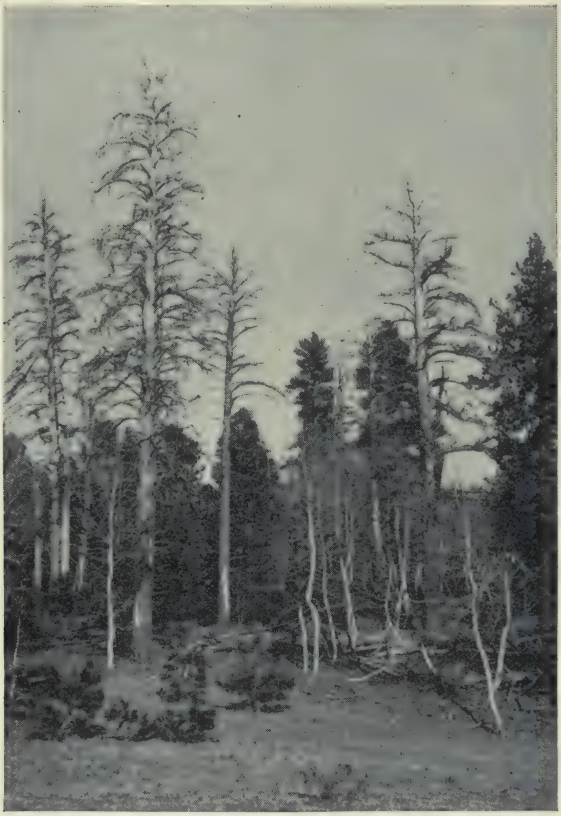

FIGURE 9.—Ponderosa pines in southern Utah killed by the Black Hills beetle. An old attack, as evidenced by loose and falling bark and loss of smaller twigs. (Photograph by Blaine Betenson, Forest Service, U. S. Department of Agriculture.)

stroy the broods; the bark must be burned. The southwestern pine beetle usually attacks overmature, lightning-struck, felled, or weakened ponderosa pines; but on occasion it builds up to a serious condition, and artificial control work becomes necessary. This beetle is often associated with other insects such as the Black Hills beetle.

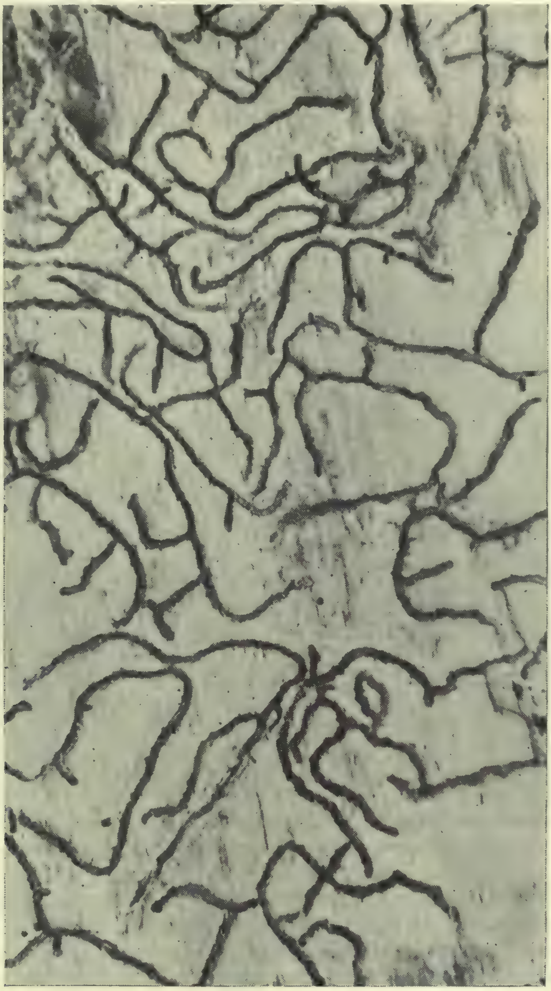

FIGURE 10.—Winding egg galleries of the southwestern pine beetle. They show in the inner bark and on the wood.

THE COLORADO PINE BEETLE AND THE ROUNDHEADED PINE BEETLE

The Colorado pine beetle (*Dendroctonus approximatus* Dietz) and the roundheaded pine beetle (*D. convexifrons* Hopk.) very closely resemble the Black Hills beetle in size and general appearance. The character of the galleries offers the most reliable means of identification. The Colorado pine beetle constructs short, winding, many-branched galleries, and the larval mines are not evident on the inner bark. The roundheaded pine beetle excavates long, wavy, or sinuous, longitudinal egg galleries, and the larval mines and some of the pupal chambers can be seen on the inner bark. These two species frequently occur in the same tree or are associated with other species in living, injured, and dying ponderosa pine trees. While it is recognized that they may occasionally attack and kill healthy trees, they usually prefer weakened trees or those previously attacked by other insects and generally are not important.

THE RED TURPENTINE BEETLE

The red turpentine beetle (*Dendroctonus valens* Lec.) is similar in appearance to the Black Hills beetle but of a reddish color and larger, being one-fourth to three-eighths of an inch long. It usually attacks the living bark on the basal portion of injured, dying, healthy, or felled pine. It more often works in fresh stumps and the lowest 3 or 4 feet of trees attacked by other insects. The beetles excavate broad, irregular, longitudinal galleries, placing their eggs in groups along the sides, and the larvae feed gregariously.

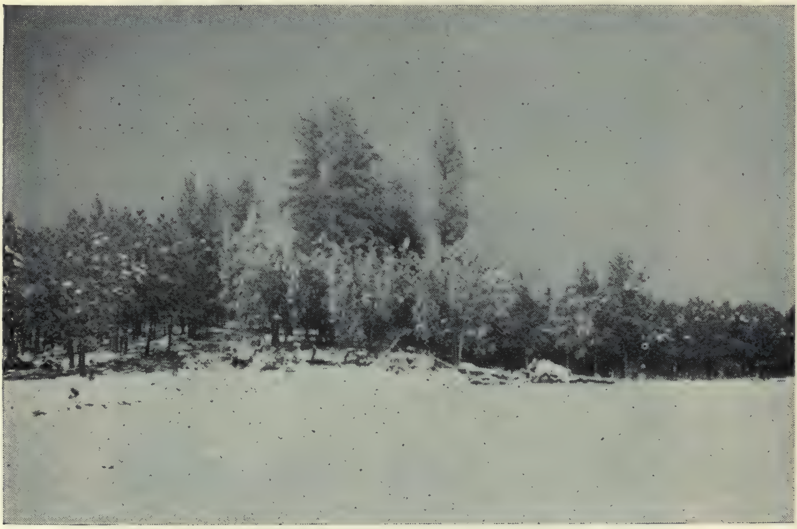

FIGURE 11.—Characteristic group killing of pole-size pine by one of the engraver beetles, *Ips oregoni*. (Photograph by L. G. Baumhofer.)

THE ENGRAVER BEETLES

Three species of *Ips*[1] are often found associated with the Black Hills beetle. They are all normally secondary insects, breeding by preference either in fresh slash, felled or broken trees, or those recently killed by more aggressive insects. During particularly dry years some of these beetles may increase and, unaided by other insects, kill groups of drought-weakened trees (fig. 11). Occasionally when they develop to large numbers in slash they will emerge and attack a group of adjacent, young, green trees. However, they do not continue to breed in green trees and are not of primary importance.

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[1] *Ips knausi* Sw., *I. integer* (Eichh.), and *I. oregoni* (Eichh.).

These engraver beetles, or *Ips* species (fig. 12, *B*, *C*, *D*), can be distinguished from the Black Hills beetle (fig. 12, *A*) by the form of the body and by the type of gallery they make. The chief difference between the insects is seen in the form of the hind end of the body. In the Black Hills beetle this is gradually rounded off in a convex manner, whereas in the *Ips* bark beetles it is scooped out and armed on both sides of this depression with minute toothlike projections.

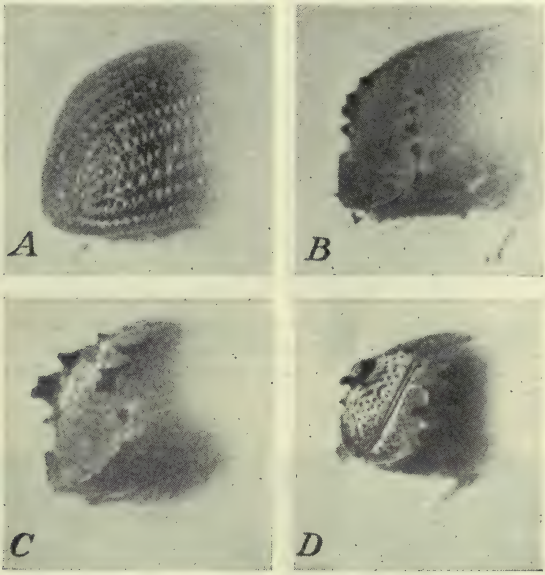

FIGURE 12.—View of hind end of adult bark beetles: *A*, The Black Hills beetle (note end of body gradually rounded off in a convex manner); *B*, *C*, and *D*, corresponding parts of *Ips* bark beetles showing hind end of body scooped out and armed with toothlike projections. (Photographs by N. D. Wygant.)

The egg galleries of *Ips* beetles have several branches radiating from a central point and are kept free from boring dust (fig. 13, *A*, *B*), whereas those of the Black Hills beetle are characteristically hooked at the lower end, long and straight, and always tightly packed with frass or boring dust (fig. 2). The grubs of the *Ips* beetles feed in the inner bark, where they develop to maturity, as is the case with the Black Hills beetle.

OTHER BEETLES ASSOCIATED WITH THE BLACK HILLS BEETLE

Many other insects besides the bark beetles are found in trees killed by the Black Hills beetle. Chief among these are the roundheaded borers or larvae of large cerambycid beetles.[2] They are com-

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[2] *Acanthocinus spectabilis* Lec., *A. obliquus* Lec., *Monochamus maculosus* Hald., *Asemum atrum* Esch., and *Tetropium velutinum* Lec.

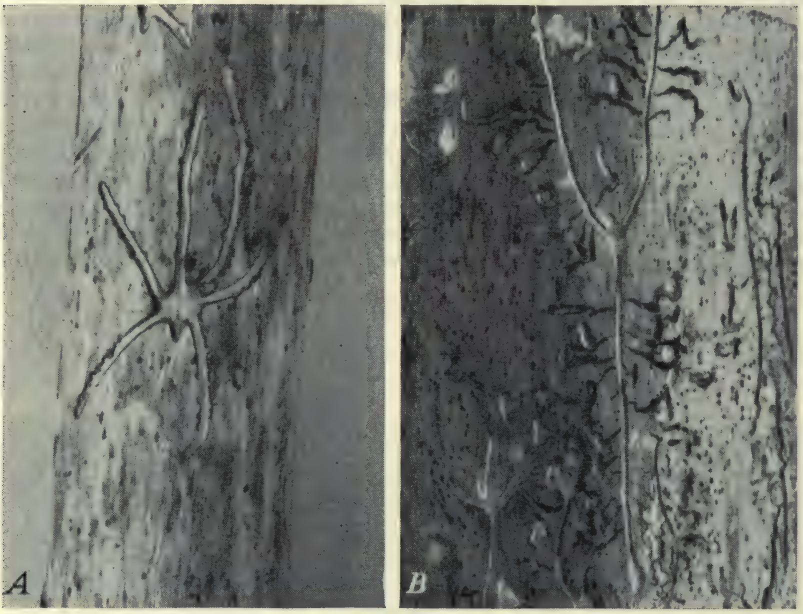

FIGURE 13.—Galleries of the engraver beetle *Ips oregoni:* *A*, The beginning of a gallery, showing the nuptial chamber, a six-branched gallery, and egg niches along the gallery; *B*, a three-branched gallery further advanced, showing larval mines.

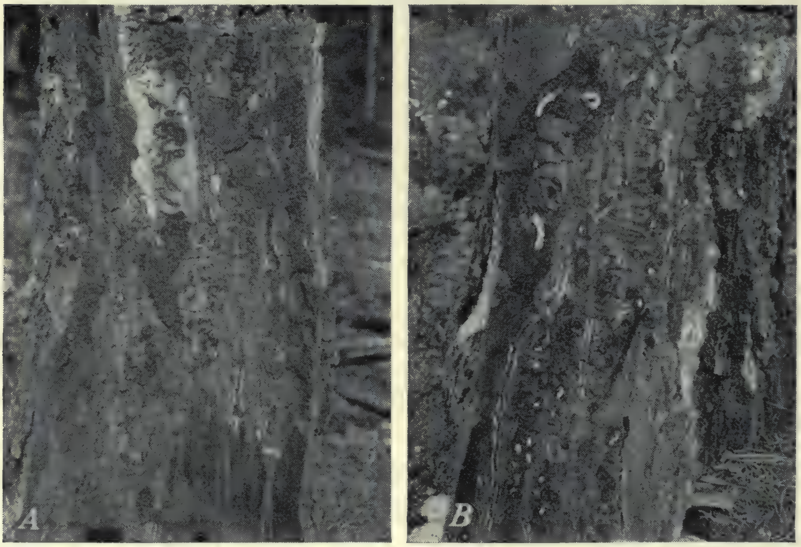

FIGURE 14.—*A*, Larval mines of roundheaded borers in the inner bark of pine; *B*, large larvae of roundheaded borer in the inner bark of pine and smaller larvae and pupae of the Black Hills beetle in pupal cells.

monly called sawyers or fish bait. The adults are large grayish or blackish beetles, and some have long feelers, or antennae. The larvae are white, elongated, legless grubs ranging from ½ to 1 inch in length. They are in no way responsible for the death of the trees, but they mine the wood of infested trees and reduce its value for lumber. These insects feed for a time in the same part of the inner bark as that required by the bark beetle brood (fig. 14). Thus they compete with the bark beetles for available food and probably destroy many of those with which they come in contact. Because of this habit they are sometimes called robbers.

NATURAL ENEMIES OF THE BLACK HILLS BEETLE

Although there are several kinds of natural enemies of the Black Hills beetle, such as insect parasites, insect predators, robbers, and birds, these are probably more important during endemic years, when few beetles occur, than during epidemic years. Several small wasplike parasites and small predacious flies have been reared from broods infesting lodgepole pine and limber pine, but very few have been noted in ponderosa pine. The larvae of several species of predacious clerid beetles feed on the brood of the Black Hills beetle beneath the bark. Some of the cerambycid larvae, as robbers, sometimes kill large numbers of the brood as they feed through the inner bark of infested pines. Woodpeckers feed on the brood at times (fig. 15), but more often prefer the larger cerambycid larvae. The mountain bluebird and a nuthatch have been reported feeding heavily upon the adults during the flight period.[3]

Unfortunately these agencies are not present in our forests in large enough numbers to prevent or suppress outbreaks, and there is no known method of increasing their effectiveness.

PREVENTIVE MEASURES

Some species of destructive bark beetles show a decided preference for mature or overmature trees, and this fact can be made use of in the management of timber stands. This, however, is not true of the Black Hills beetle, for, while this beetle does choose the more slowly growing or weakened trees under endemic conditions of infestation, no such choice is evident during an epidemic. In fact, the trees killed by the beetle in large-group killings are often found to have been growing more rapidly than those not attacked.

Logging operations during the flight period undoubtedly remove a great many beetles from the woods, since the beetles are often attracted to freshly felled logs. In this connection it is worthy of note that there is no record of a serious infestation of this beetle ever having been built up in or near an area where continuous logging was in progress.

It is easier and far less costly to prevent serious outbreaks of the Black Hills beetle than to bring them under control after they have made considerable headway. The best way to do this is to keep a careful watch of forest areas in which epidemics may develop. Pine forests in the Rocky Mountain region should be examined periodically. Where infested and dying pine trees in groups of even three to five are found they should be examined for evidence of the Black Hills beetle. Observations should also be made on the extent of killing in the area. Where this insect appears to be on the increase, a systematic survey should be made to determine the need for control work. If any doubt exists as to the identity of an insect found infesting trees or as to the advisability of control, specimens, together with complete information concerning the infestation, should be sent to the Forest Insect Laboratory, Bureau of Entomology and Plant Quarantine, Fort Collins, Colo.

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[3] The Bureau of Biological Survey of the U. S. Department of Agriculture has made a study of the food of birds by examining the contents of the stomachs of large numbers of them. They report that the following have fed on insects of the genus *Dendroctonus:* Nighthawk, chimney swift, white-throated swift, Lewis's woodpecker, hairy woodpecker, American and Alpine three-toed woodpeckers, olive-sided flycatcher, white-breasted nuthatch, dipper, Bewick's wren, hermit thrush, yellow-throated and blue-headed vireos, American magpie, and English sparrow.

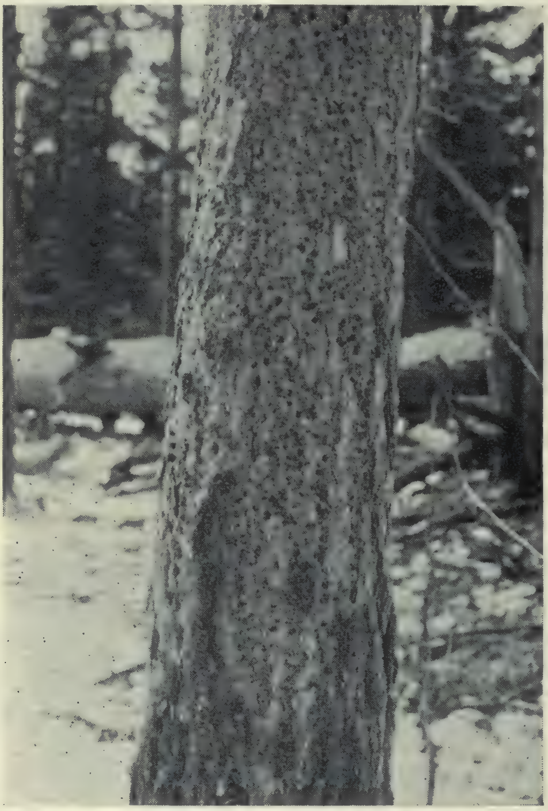

FIGURE 15.—Work of woodpeckers searching for larvae of the Black Hills beetle and other grubs in an infested tree.

CONTROL MEASURES

Before control work against the Black Hills beetle is considered in any particular forest area a general reconnaissance examination should be made to determine the location, nature, and extent of the infestation. This can best be done by the topographic or red-top survey method where a large part of the forest can be viewed from open valleys, ridges, or lookout points. This examination should take into consideration not only the currently infested trees on the area but also the number of "red-top" trees as well. Since the trees with considerable red foliage usually indicate the amount of infestation the previous year, a comparison of their number with the number of newly infested trees will show the trend of the infestation, whether it is increasing, decreasing, or merely holding its own. Some trees retain part of their needles for two or three seasons, and it is necessary to distinguish those from trees killed the season prior to the examination. Some further idea of how many emerging beetles may be expected may be obtained by felling a number of infested trees early in the summer and noting the number of live brood beneath the bark.

If control measures are advisable, the general examination should be followed by a survey, or cruise, to determine more accurately the boundaries of the infestation, to locate the areas of damage, and to obtain an estimate of the number of trees requiring treatment. Without such a survey it is difficult to organize the control work efficiently and effectively. The extensive survey should be conducted by the sample-strip method. In using this method the observer travels along compass lines, pacing the distance, and counting the infested trees on a strip of designated width (usually 1 chain wide). On large areas involving many thousands of acres in the lodgepole pine type, a 1¼-percent survey will usually give a fair estimate of the total number of infested trees. On smaller areas a relatively more extensive survey is necessary for an accurate estimate. On extensive areas of ponderosa pine a 2½-percent survey is usually required for comparable results, because of fewer trees per acre, and where only a few thousand acres are involved a survey of between 5 and 10 percent is advisable.

In the lodgepole pine type, if the survey shows an aggressive infestation where groups of three to five infested trees are found and they average as much as 64 trees per section, control work should usually be undertaken, especially where the timber is of economic importance or adjacent valuable pine stands are threatened. In the ponderosa pine type, however, control work is undoubtedly advisable with a much smaller number of infested trees per section, on account of the much larger size of the trees and the relatively small number per acre. Under forest conditions an infestation in this type should usually be treated if it includes as many as 20 trees per section, particularly if the infestation is increasing. In highly scenic areas or where trees have a high aesthetic or other great value, control work is warranted in a much lighter infestation. In many such cases even occasional individual infested trees should be treated.

When control work is undertaken the infested area should be fully covered by spotters, assigned to locate and mark all infested trees (fig. 16). The blazed trees should be numbered and marked on a map, so that they can be readily found by the treating crews. Spotters should be carefully trained to recognize the trees that need treating and to differentiate between them and those with old attacks, or pitched-out attacks, which should not be treated. The success of the project often depends in a large measure on the ability of the spotters and their success in locating and marking all infested trees and in leaving the uninfested ones. Of course their work must be followed by that of well-organized, efficient control crews.

Control work directed against bark beetles is aimed at the destruction of the immature stages of the insects before they have abandoned the infested trees. The main object is to destroy as nearly 100 percent of the infestation as is physically possible. Any method that will bring about the desired result may be used, but the one best adapted to local conditions peculiar to the area to be treated should be selected.

LOGGING

Where concentrated infestations occur in valuable pine timber accessible to lumber markets, control work can often be done at relatively little cost and sometimes even with a small profit. The infested trees are felled, cut into log lengths, and transported to the mill, where they are sawed into lumber and the slabs containing the insects burned. It is essential that these slabs be burned several weeks prior to the emergence period of the beetle. The bark on all infested portions of the trees remaining in the woods, such as stumps, long butts, large crooked top logs, large limbs, etc., must either be peeled while the insects are in the larval stage, or be burned before the beetles emerge.

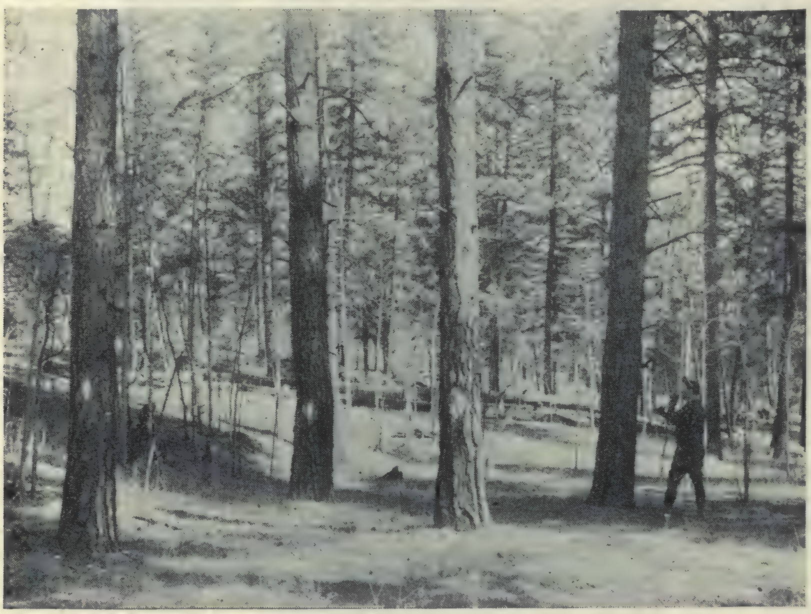

FIGURE 16.—Pine trees newly infested by the Black Hills beetle being marked for treatment. Attacks are frequently made on the better growing, more vigorous trees.

This method is not applicable in either inaccessible areas or scattered infestations or in timber stands of low commercial value. Lumber cut from beetle-infested pines is usually badly stained by the fungus introduced by the beetles and because of this blued condition is frequently not accepted for some uses. The prejudice against blue-stained lumber for structural uses or for finishing where the surface is to be painted is unjustified, for such lumber retains its normal strength and is just as serviceable as unstained lumber.

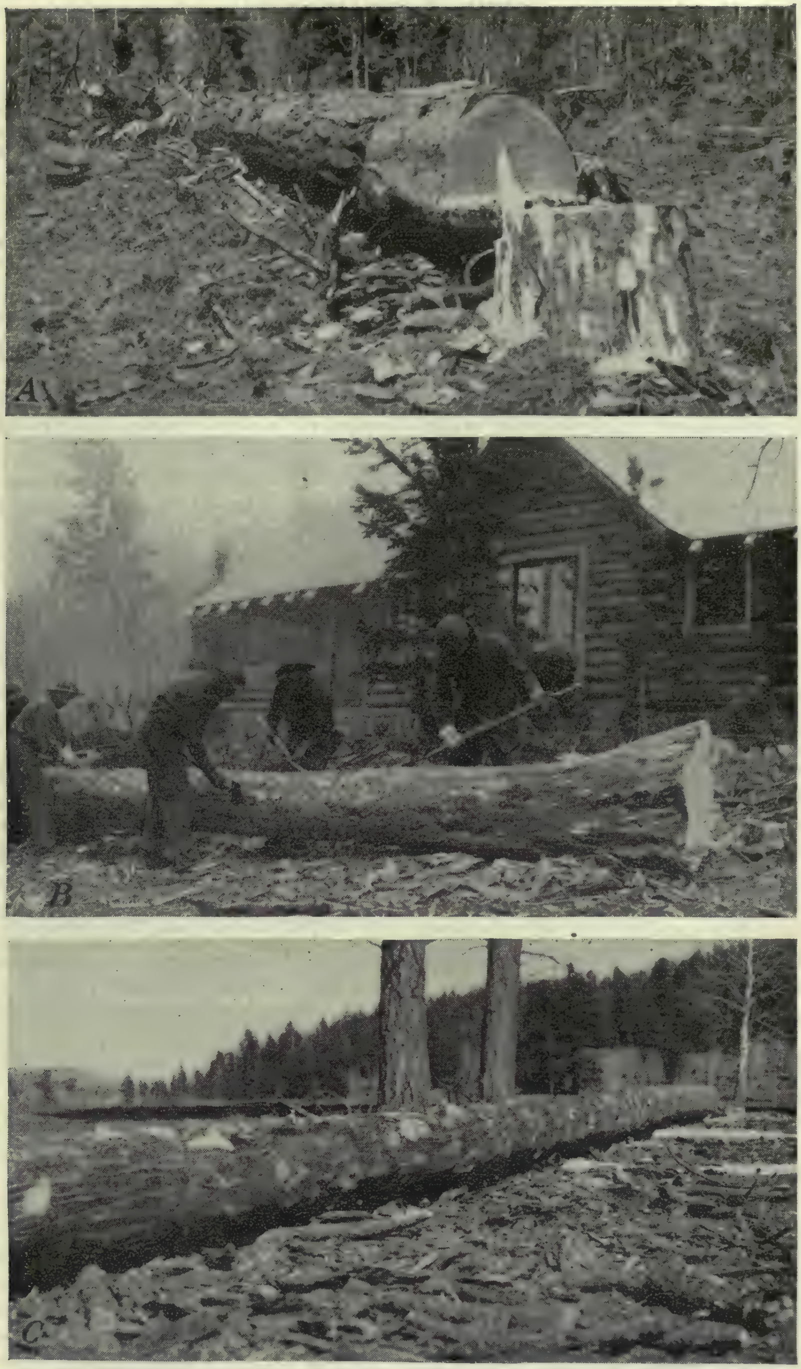

FIGURE 17.—Destroying broods of the Black Hills beetle: *A*, A single infested pine felled and prepared for burning as soon as conditions are safe for fire; *B*, treating an infested pine by the felling and peeling method (note peeling tools, or spuds, being used); *C*, an infested tree treated by the felling and peeling method. Note the galleries of the Black Hills beetle on the wood. (*A* and *C* photographed by Blaine Betenson.)

PEELING THE INFESTED BARK

Another method is to fell the trees while the broods are in the larval or grub stage and remove all the bark from the infested portions of the bole, stump, and base of large limbs, by the use of either axes or spuds (fig. 17, *B* and *C*). The uninfested upper bole, above the highest beetle gallery, need not be peeled. This part of the tree is usually filled in by *Ips* beetles during the spring, but these should be disregarded. Peeling turns the developing broods out of their natural surroundings beneath the bark, and they dry out and die or are consumed by other insects such as ants, or by mice or birds. Short trees or those containing broods only near the ground can sometimes be peeled with long-handled spuds without being felled. The peeling method can be used whenever it is desirable to save the treated boles for fuel or other purposes, or where conditions prohibit the use of fire. It must, however, be used only when the insects are in the immature stages and should never be used when any number of the brood have reached the adult or beetle stage. The effective period for peeling extends through the fall, winter, and early part of spring, usually from the middle of September to the first of June.

BURNING

Infested trees can be felled and burned. The burn should be sufficient to char the entire bark, and thus insure a complete kill of all the brood (fig. 18). It is advisable to buck small trees into short sections so they can be decked and burned (fig. 18, *A*). Sometimes trees can be felled parallel and close together or skidded together so they can be burned in a group without being sawed into shorter lengths. Trees too large to be handled in this way can be burned where they fall, by piling dry sticks, limbs, and brush along the sides and top of the trunk to insure a good burn (fig. 17, *A*). Hacking the bark along the top side of the tree trunk also insures a better job of burning on this often-difficult part and eliminates the need for peeling it. Fires should be located with care, in open spots if at all possible, so as not to scorch the foliage or bark of nearby trees or reproduction. Only enough fire should be used to kill the insects beneath the bark, as additional burning is a waste of time and money. The correct degree of burning will vary with the project and the weather conditions from day to day. The project foreman should keep a close watch of all treating activities and handle the work according to the conditions. Fire lines should be raked around each deck, group, or single tree before the fire is started and the debris thrown on the fire. Every precaution must be used to prevent such fires from spreading.

Burning costs about the same as peeling but successfully disposes of most of the slash. If burning conditions are safe, it can be used as a control measure from the time the trees are attacked until just prior to the time the beetles fly the following summer. Fires cannot be used indiscriminately, however, for some areas become too dry to permit burning, and careless use of fire often results in serious browning of nearby green trees. When it becomes unsafe to use fire in control work, peeling can be resorted to up to the time the brood begins to transform to the adult or beetle stage early in June.

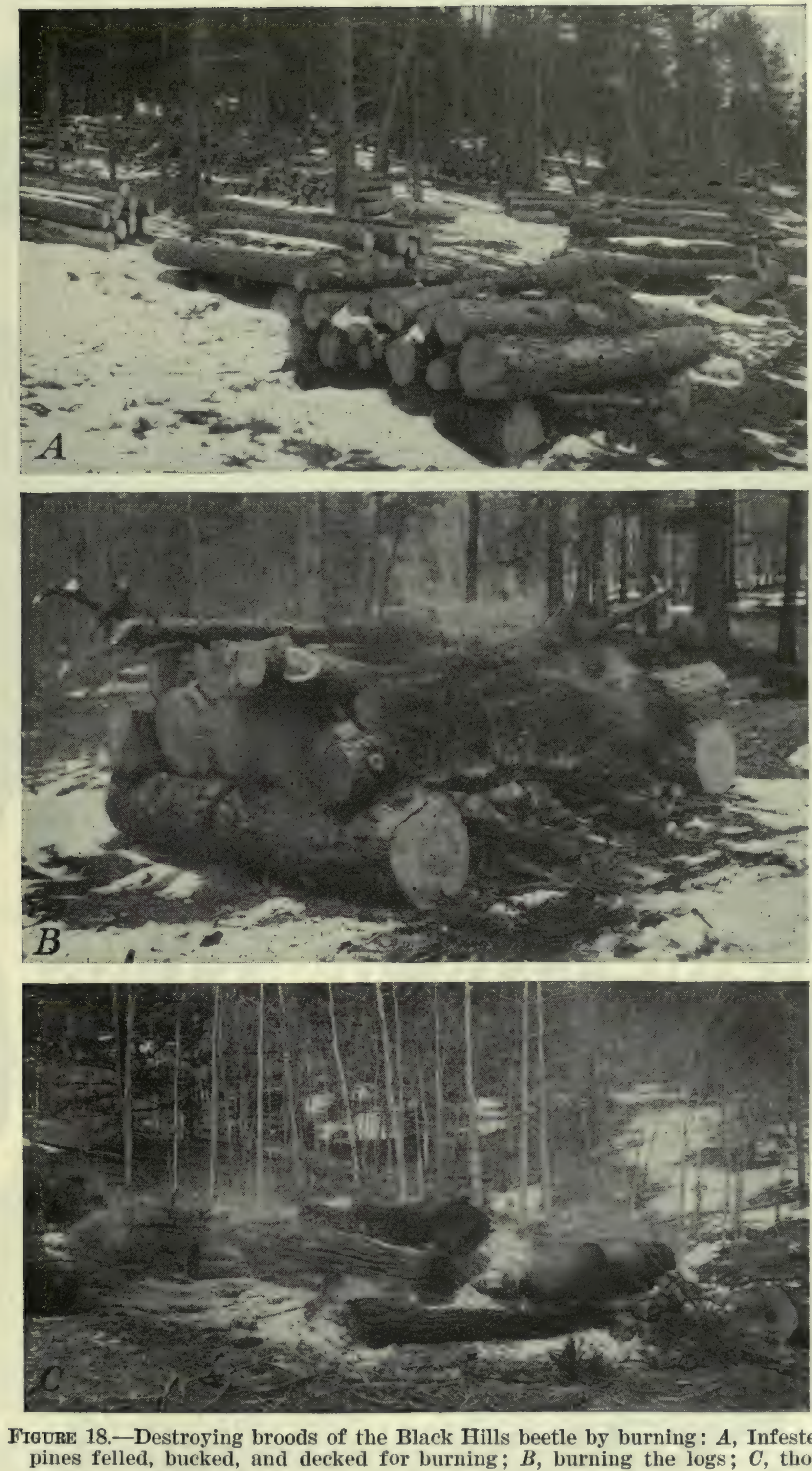

FIGURE 18.—Destroying broods of the Black Hills beetle by burning: *A*, Infested pines felled, bucked, and decked for burning; *B*, burning the logs; *C*, thoroughly charred logs.

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SAND-DUNE RECLAMATIO
in the
SOUTHERN GREAT PLAINS

Farmers' Bulletin No. 1825
ited States Department of Agriculture

AMONG THE MOST STRIKING manifestations of the destruction of soils and crops by the windstorms of recent years are the gigantic sand dunes that have formed on some of the lighter soils of the Great Plains.

Specialists of the Soil Conservation Service who were assigned to a study of the problem have been successful in devising methods by which these immense piles of sand, which have covered cultivated lands and good native sod, can be leveled and stabilized. Of still greater value to the farmers and ranchers in areas subject to this soil shifting are the methods of cultivation and land use that recent study and experiments have revealed as the best means of protection against the formation of dunes.

This bulletin is written for the benefit of those farmers and ranchers who are faced with the problem of protecting their lands against possible damage from dune formation or with the more immediate problem of restoring lands that have been made temporarily useless by the invasion of these monstrous wind-blown piles of sand.

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SAND-DUNE RECLAMATION IN THE SOUTHERN GREAT PLAINS

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INTRODUCTION

During the past 5 years the effects of wind action on soils in the Great Plains have been brought forcibly to the attention of the people of this country by the yearly occurrence of numerous dust storms. At Dalhart, Dallam County, Tex., 61 dust storms were reported in 1935, 45 in 1936, 60 in 1937, and 71 in 1938. Other sections of the Great Plains have experienced similar conditions to a greater or less degree. Another striking manifestation of wind action in certain areas is the formation of sand dunes.

The wind was able to build up these dunes only after surface cover had been destroyed by cultivation, by heavy grazing, by heat and drought, by abrasive action of moving soil particles, by covering of the plants, by in-drifting of soils, or by a combination of these factors. They are a recent development on the Great Plains. Ten years ago there were no active dunes of this origin on many of these lands. These dunes have no plant cover (fig. 1) and should not be confused with the long-established dunes that are also the result of wind action but are now stabilized by vegetation. Nor should they be confused with the "blow-out" type of dune that develops near wells, roads, and cattle trails.

The dunes are valueless in their present condition. Moreover, they are a constant menace to surrounding fertile farm lands, pastures, and buildings because the sands are continually shifting. Many of these immense piles of sand are now found on areas of native prairie sod that were never cultivated. In Dallam County these dunes developed on land that was formerly fine sandy loam and loamy sand—soils that produce good crops but that tend to drift and blow during the spring winds unless protected by adequate cover.

Scattered sand-dune areas of recent origin occur throughout the Great Plains in Texas, New Mexico, Colorado, Kansas, Nebraska, Wyoming, South Dakota, and North Dakota. They are most extensive between Curry County, N. Mex., and Seward County, Kans. At least 12 dune sites are to be found in Dallam County, Tex., alone.

Little or nothing seems to have been done about sand dunes in the southern Great Plains until early in 1936 when the Soil Conservation Service established a study area to determine the best means of controlling these dunes and reclaiming the dune land.

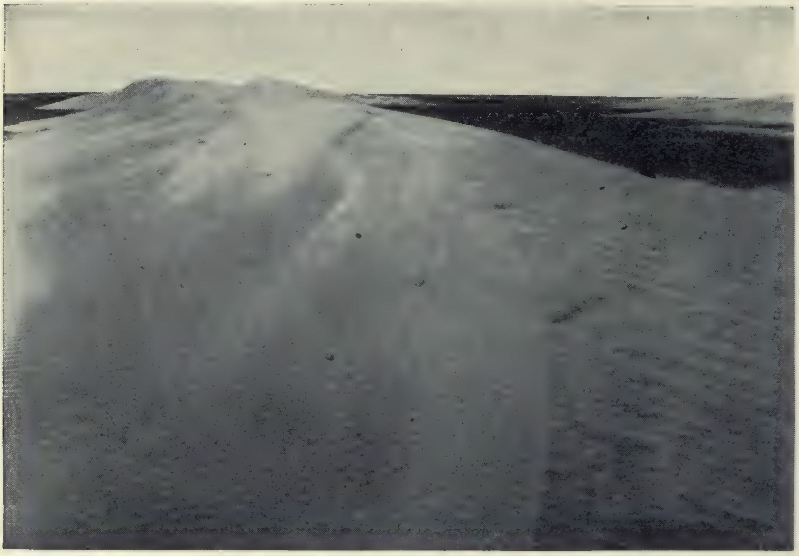

Figure 1.—A typical sand dune before being treated. This dune is approximately 22 feet high.

THE STUDY AREA

Two thousand acres of sand-dune land in Dallam County, Tex., 8 miles north of Dalhart, were used for studying and devising methods for stabilizing sand dunes and making them eventually useful for grazing and cultivation. The methods used on this study area are described here to serve as suggestions for treatment of other sand-dune areas.

The sand dunes were of various dimensions. One 470-acre field on the study area that was surveyed in 1936 had approximately 57 sand dunes, ranging from 1 to 9 feet in height and averaging 161 feet in length and 113 feet in width (fig. 2). The subsoil around and between the dunes was hard and eroded to a depth of 10 to 12 inches. In 1930 this field was dominated by native vegetation, with blue grama, side-oats grama, and bluestems as the principal grasses and sand sage as the outstanding shrub. In 1931 it was cultivated for the first time and planted to sorghums in 40-inch rows. It was planted to row crops again in 1932 and in 1933. Because of drought and crop failure only one crop was harvested during this 3-year period. The land lay idle from 1933 until the experimental work was started in the fall of 1936. The front cover shows an aerial view of the area in March 1937. The pure-white part is the actual dune at the time the picture was taken. The dull gray is the hard, eroded land, that part of the original dune site from which the sand has blown away since the area was listed. The striped part is the listed hard area with sand blown into the furrows. Figure 3 shows hegari that was growing on the area in the fall of 1937. In April 1938 nearly all these dunes had disappeared, and their materials had been redistributed into either plant-litter or lister furrows.

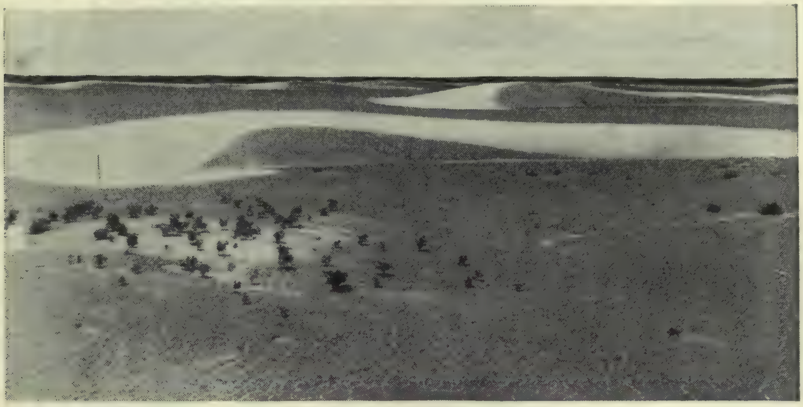

FIGURE 2.—Some of the 57 sand dunes developed on this field during 1934 and 1935. In the foreground is hard eroded land.

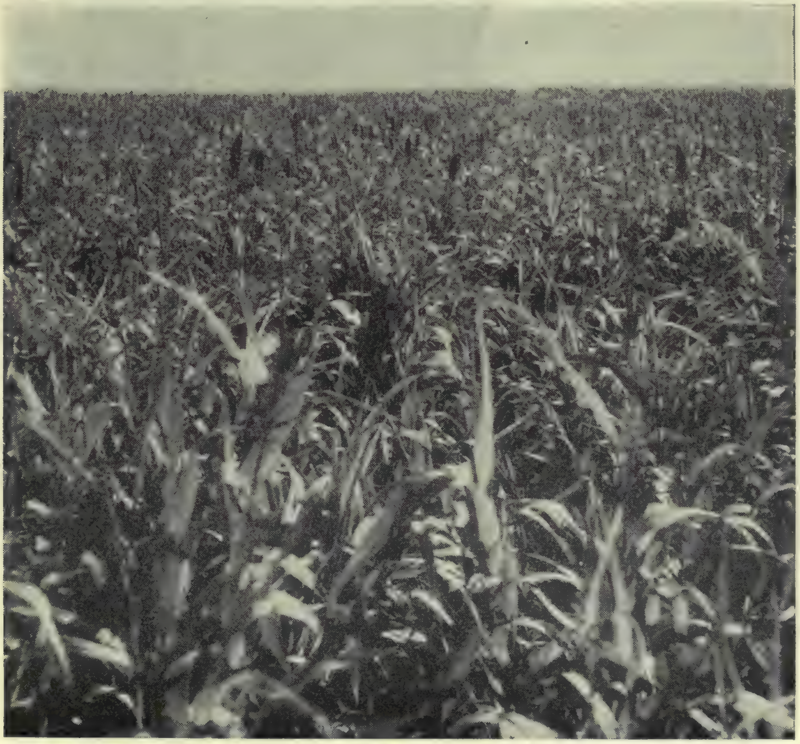

FIGURE 3.—Hegari was drilled for a cover crop on part of the field shown in figure 2. This photograph was taken 14 months later.

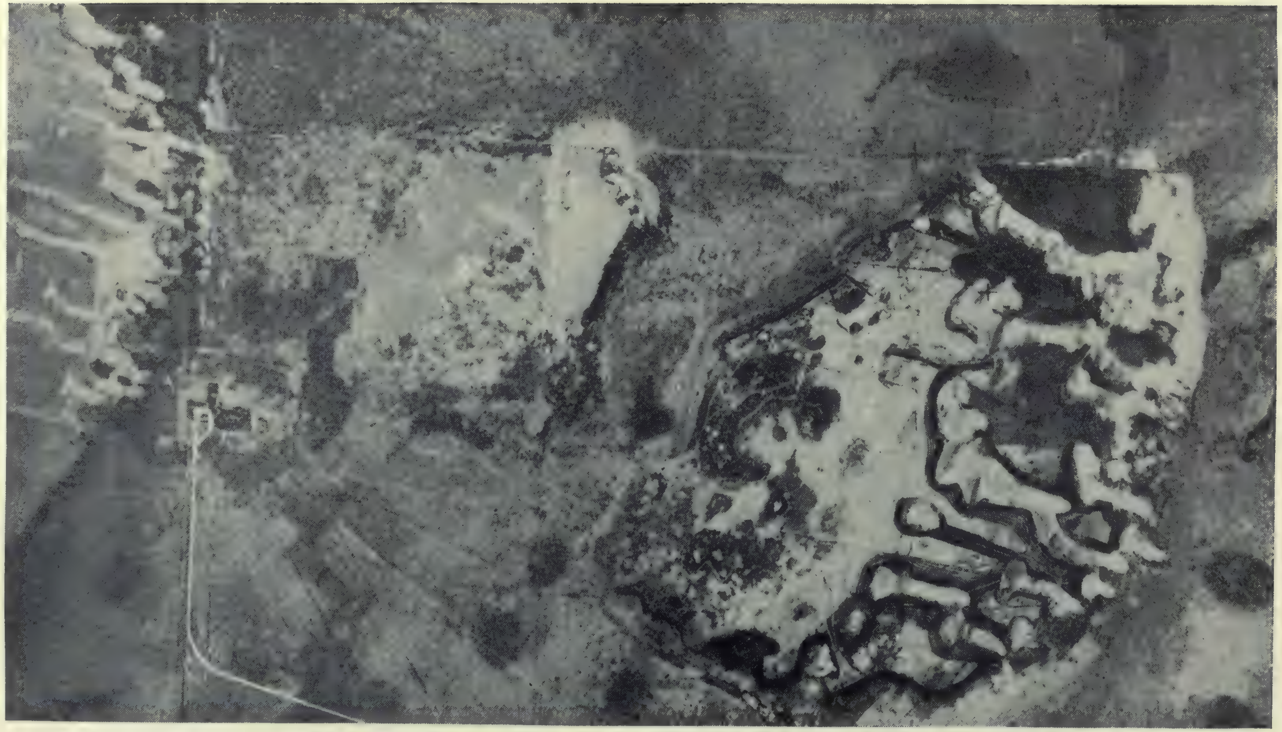

Figure 4.—Aerial photograph of the sand-dune study area. On the extreme left is the untreated check area, with dunes and hard eroded land. On the right is the dune site that has been treated. Listing around the dunes and wind channels across the dunes are shown.

In another field, which is some 400 acres in extent and is in the study area, the sand dunes are on land that has never been cultivated (fig. 4). They have developed as a result of wind erosion on 80 acres of land southwest of the present dune site. This land was cultivated from 1907 to 1914 and was then abandoned and used for grazing. Evidences of dune formation were first noticed about 1926. Since 1929 striking changes have occurred; dunes have developed from low mounds to heights of 26 feet. These dunes are large piles or mounds of sand or sandy materials. They range from 50 to 880 yards in length and are usually about 30 yards wide. Their height apparently depends on their age and the direction and velocity of the wind. The highest dune measured was 26 feet in elevation. Owing to the prevailing wind direction, which is generally from the southwest, the axes of most of the dunes is east and west, but a few are slightly southeast and northwest. The dunes are irregularly spaced; the distance between them ranges from 50 to 400 yards. They are generally compact beneath and moist a few inches below the surface.

The subsoil on which the dunes rest, as well as the soil between and around them, is very compact, hard, and fairly level. It consists of the subsoils of uncultivated land that has been eroded by wind to various depths, in some places to as much as 4 feet. The prevailing winds, from the southwest, have left large areas of hard land to the west and south of the dunes and accumulations of sand from 6 inches to 2 feet deep to the north and east.

A border exists between the range grassland and the eroded hard lands and dune lands. It is called the critical area because a hummocked condition and piles of loose sand devoid of vegetation make it susceptible of dune development and because the wind sweeps unhindered across the hard lands, picking up materials as it goes.

STABILIZING THE SAND-DUNE AREAS

Effective treatments of these badly damaged areas must be based on attempts to stabilize them permanently. The best means of accomplishing stabilization seems to be through the reestablishment of a plant cover. Vegetation tends to prevent soil movement (1) by reducing the wind velocity at the surface and (2) by binding the soil with the roots of the plants. In their present state, several factors are preventing these sand-dune areas from becoming stabilized through natural revegetation. In the first place the mechanical effects of the wind, owing to the dust and sand it carries, tend to prevent vegetation from starting and also to cut off the already-existing plants. As a result of obstructing the sweep of the wind by roughing the soil and planting strips of row crops along the border, dense stands of weeds developed over the hard eroded lands on an experimental plot. On the check plot, where no strips were planted, there was very little weed growth. In addition to the mechanical effects of the wind, the physical characteristics of the dunes themselves —height, shape, and continuous sand movement—make it difficult for plants to get started and to maintain themselves.

On the study area the following steps were taken to reclaim the sand-dune sites: (1) Controlling the critical area, (2) leveling the sand dunes so they could be planted, (3) deep listing between and around the dunes to catch the sand and to build on the hard eroded subsoils, and (4) planting to prevent additional soil movement.

CONTROLLING THE CRITICAL AREA

The critical area, that strip of hummocked sandy land lying between the sand-dune area proper and the native pasture, was the first piece of land treated. A tractor, a No. 2 terracer or a road grader, and a railroad iron were used to level the hummocks. The area was deep-listed and planted to sorghums during the planting season. The resultant crop held the sandy material, preventing it from being blown across the hard land and onto the dunes.

LEVELING THE SAND DUNES

Reclamation of wind-eroded land by machinery is sometimes too expensive to be justifiable unless the menace to adjoining areas is serious. The development of methods by which the land could again be made valuable for agriculture or grazing was the principal problem confronting the Soil Conservation Service. The most practical method of lowering the dunes enough so that they could be effectively planted involved the utilization of wind to redistribute the materials that this same force had piled into dunes up to 26 feet in height.

Investigations have shown that far more material is accumulated than lost by untreated sand dunes. In fact sand dunes after they get above 8 to 10 feet in height have a tendency under ordinary conditions to keep building higher. One of the main problems that faced the investigators was to get the sand to move from the dunes out onto the hard eroded land. This was especially true if the leeward slope was steep. In order to decrease the height of the dunes to a point where they could be effectively planted, four means were employed to aid the movement of the sand, namely, wind intensifiers, drag poles, one-way disks, and tractors and blades.

WIND INTENSIFIERS

Three types of wind intensifiers were used—the signboard, the sandbag, and the wind channel. The signboard was constructed by nail-

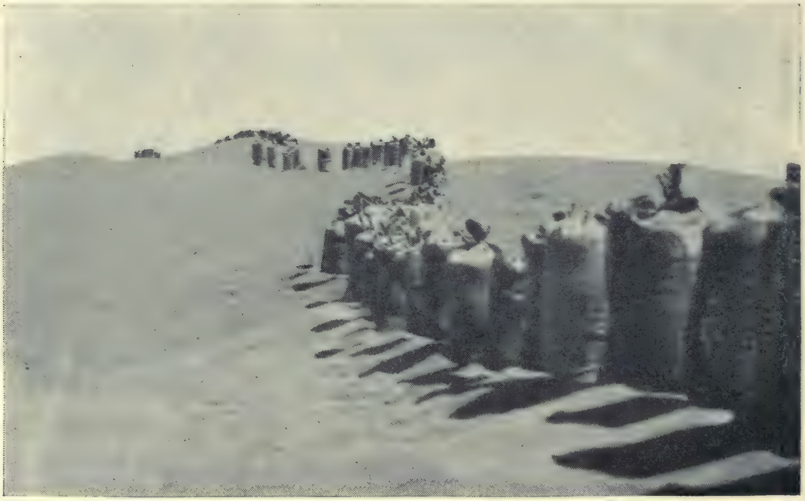

FIGURE 5.—Gunny sacks placed on the crest of dunes act as wind deflectors and lower as the wind removes the sand from under them.

ing galvanized iron or boards between posts at different heights above the sand level on the crest of the dune (fig. 8). Gunny sacks were filled with sand and placed at different spacings on top of the dune (fig. 5). These wind intensifiers were placed on the sharp edges of the dunes, which are always on the leeward side. Channels generally 3 feet wide and 4 feet deep were dug across the dune. Some of these channels can be seen in figure 4.

These methods proved very efficient in moving sand. Gaps 4, 5, and 6 feet deep were dug out, and the sand was carried out beyond the crest. The sandbags proved most effective since they lowered as the wind removed the sand from around them. During one storm, by the use of sandbags, a dune was lowered about 2 feet. The crest of the dune flattened down, and the dune itself moved forward 6 to 10 feet. During another storm the crest was lowered 1 foot. The only part of the dune affected in this manner was that on which the sandbags had been placed.

The use of wind intensifiers in lowering dunes is practical, however, only if manual labor is available.

DRAG POLE

A second method of destroying the steep slope and crest to the leeward side of the dunes, and thus allowing the wind to carry the sand out beyond, is the use of the drag pole (fig. 6). The drag pole is an 8- by 8-inch timber. A 20-foot pole should be sufficient for the largest dune. One or two horses are hitched to one end of the pole, and two or three horses to the other or top end. It is dragged along the sharp edge of the dune at right angles to the crest. Attaching a disk at the top aids in breaking down the steep slope.

The drag pole can be used more advantageously than the wind intensifiers because it requires less hand labor and a greater area can

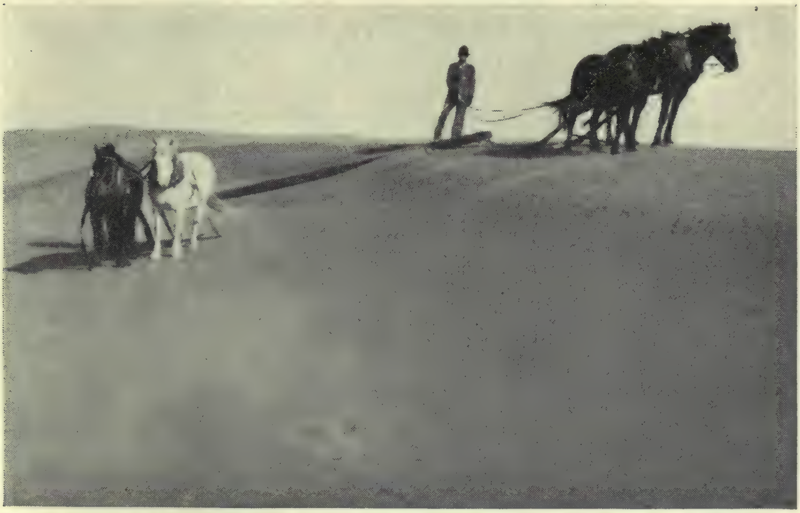

FIGURE 6.—A drag pole being used to break the crest of a dune.

be covered in a short period of time. By use of the drag pole, as by the use of intensifiers, the wind is prevented from forming eddies, and as a result it carries huge quantities of sand out beyond the dune. After the crest or the steep leeward slope is destroyed, the dune has a flatter, more oval shape and does not present an obstruction for the wind. Therefore, the wind velocities are not reduced, and the load of sand is not deposited on the dune but moves across and is deposited in the lister furrows, cover crop, or any other obstruction that has been prepared or grown. The entire dune seems to move forward after the crest has been broken down. One dune on which a drag pole was used was lowered 15 feet in 6 months and broadened out along its entire length an average of 24 feet.

ONE-WAY MULTIPLE DISK

The sandy material making up a dune often becomes compact, owing to trampling of stock, to rain, or to the weight of the sand itself. The best way found to loosen this sand so that it can be moved by wind action is by the use of a one-way disk plow. Disk harrowing the dunes with teams is economical as well as effective.

TRACTOR AND BLADE

Another method employed to spread the sand is the use of a tractor and blade to flatten and level the dunes. Quick results are then obtained by wind action. In 6 months one 20-foot dune was lowered to 5 feet by this method.

The procedure with the blade is to make 1 to 3 turns over the highest points of the sand dune. This gives the wind a chance to move the loose sand. From 6 to 12 treatments are usually necessary in order to affect the height of the dunes materially.

DEEP LISTING THE HARD ERODED LAND

One method employed to prevent the sand moving from one dune from accumulating on another is listing the hard, eroded land around and between the dunes. The furrows not only catch the material blown off the dunes (fig. 7) but also prevent more sand from accumulating on the dunes. The great importance of deep listing cannot be over-emphasized. It has been observed that shallow-listed land has continued to blow, whereas deep-listed areas have not blown, owing to the greater amount of claylike cloddy materials brought to the surface. Relisting has been done over much of the area. The soil, even that which was badly eroded, has been mixed with sand from the dunes and with other wind-blown material to such an extent that crops have been produced on most of it, which otherwise would not have grown any vegetation.

As a result of listing the hard eroded lands and cutting off some of the mechanical action of the wind by treatment of the critical area, vegetation—mainly Russian-thistle—has developed on many formerly barren areas. Although this cover is weedy and only temporary, it is

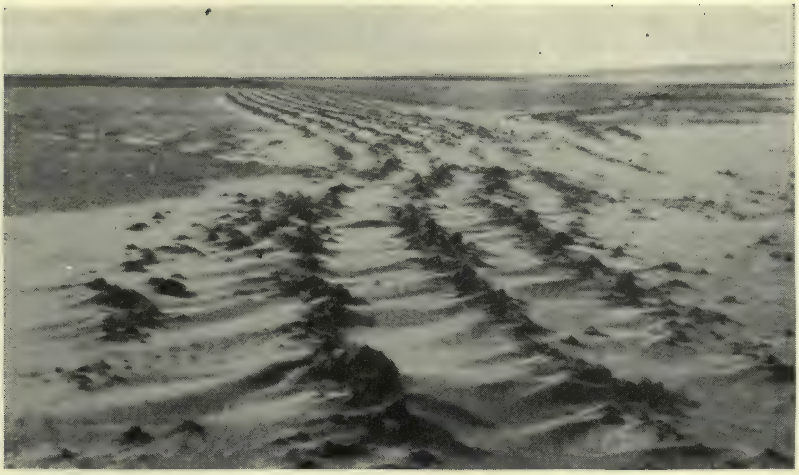

FIGURE 7.—Deep furrows catch the sand that moves off the dunes, and the land is put in a condition to plant.

sufficient to prevent blowing and even to catch and hold the moving sand that blows from the dunes.

PLANTING TO PREVENT MORE SOIL MOVEMENT

The development of a plant cover, whether a cultivated crop or native vegetation, is necessary for complete stabilization. A dense cover will prevent the soil blowing that is the source of dunes. The fine sandy soils composing the dunes, if properly managed and supplied with sufficient moisture, are capable of producing the abundant vegetation that is essential to permanent stabilization. These lands are especially adapted to the production of grain sorghums that will produce a cover crop adequate to protect the soil against erosion during the windy season. On the other hand, these areas are very susceptible to erosion and unless properly handled during good and poor years, the soil will blow, as has been shown. Because of this, it may prove beneficial to return these lands to their original grass cover. In any event, the planting of sorghums or the development of a weed cover is essential, not only to protect the soil from drifting but also to put it in shape so that grasses can be successfully reseeded.

CROP PRODUCTION

The successful farming of these sandy soils depends on conducting tillage and cropping practices in such a manner that the soils will be most resistant to soil movement. Deep listing, drilling, wet cultivation, and the leaving of sufficient crop residues on the ground are important control measures.

Deep listing is much more desirable on sandy soils than shallow listing. Turning up a cloddy, rough surface by deep plowing leaves the soil better protected for long periods and more capable of withstanding the cutting action of the drifting sand. As the furrow produced by deep listing will hold much more eroded material, the effects of deep listing will last considerably longer. Determining whether the crops are to be listed or drilled is of great importance. Although listing is more effective than drilling in conserving moisture, the cover crop produced is not so efficient in protecting the soil from drifting. During the years when the soil moisture and other conditions are favorable at planting time, crops should be close-drilled instead of planted with a lister. During periods of unfavorable conditions however, a cover crop is more likely to be obtained by planting with a lister. If crops are listed in deep sandy soil, listing should be done during or immediately following a rainy period. A crust then forms on the soil surface, preventing soil movement to a considerable extent and thereby keeping crop seedlings from being covered by moving sand. Wet cultivation, for this reason, is very desirable at any time but especially when winter or spring listing is done.

One of the most important factors governing the resistance of sandy soils to blowing is the amount of crop residue left on the ground after harvest. Leaving the entire stalk on the ground after heading seems to be more desirable than leaving only a stubble, provided an average crop has been secured. Measurements indicate that fields with stubble are losing some soil materials, whereas those with stalks are holding the soils. If, however, the stand produced was poor and the soil is in condition to blow, the stalks may cause hummocking—in which case stubble would be better. Leaving the whole stalk protects the lister ridges and prevents them from being eroded. A close-drilled stubble is more effective than a listed one in holding stalks that are mowed and allowed to fall to the ground. The stalks have a greater tendency to blow away on a listed field.

On those fields where it is necessary to remove forage it seems to be much more desirable to cut and remove the feed rather than to graze the crop. If the forage is cut, a stubble at least 10-inches high should be left.

Of the six crops studied—Sudan grass, broomcorn, kafir, hegari, millet, and black amber cane—the four most desirable for cover were broomcorn, Sudan grass, kafir, and hegari. Broomcorn made a better growth under a great variety of soil conditions than any other species with the possible exception of Sudan grass. It is also drought-resistant and effectively protects the soil from drifting.

The planting time for sandy areas depends somewhat on the rainfall. It is advisable to plant the first part of June in order to prevent the plants from being in a critical stage of growth during the dry period in July. If large acreages are to be planted, however, it may be desirable to start operations about May 20, or as soon as favorable moisture conditions prevail. According to results secured at the Dry Land Field Station, near Dalhart, Tex., kafir, milo, and hegari should be planted in the order named.

Rye has been used as a winter cover with varying success on sandy lands. Wherever the stands have been good, soil movement has been controlled throughout the blowing season.

In the spring of 1936 work was started on the denuded sand-dune area shown in figure 8. From the hard eroded land in the foreground the soil had been removed to a depth of 2 feet. The roughened surface indicates the cutting action of the wind. Eroded materials had piled up as much as 26 feet in the dunes in the background. By the fall of 1937 the excellent cover shown in figure 9 was growing on this area, although only 12.5 inches of rain, about two-thirds the normal amount, had fallen during the entire year.

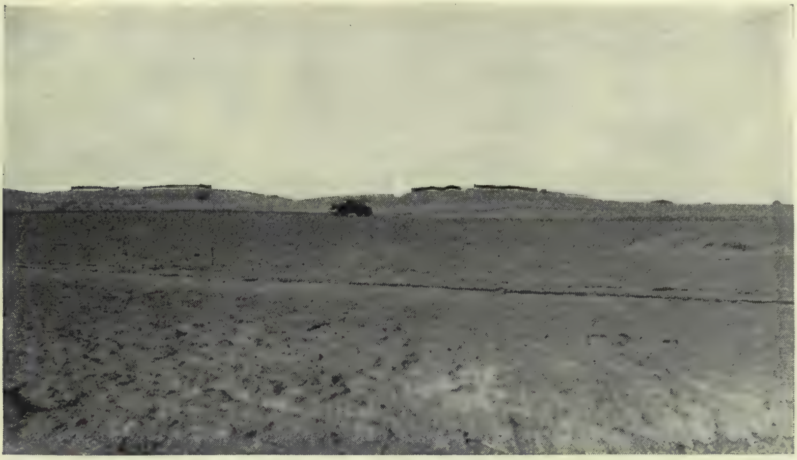

FIGURE 8.—Severely eroded land in the project area. On the crest of the dune is a signboard type of intensifier, made of boards and galvanized iron.

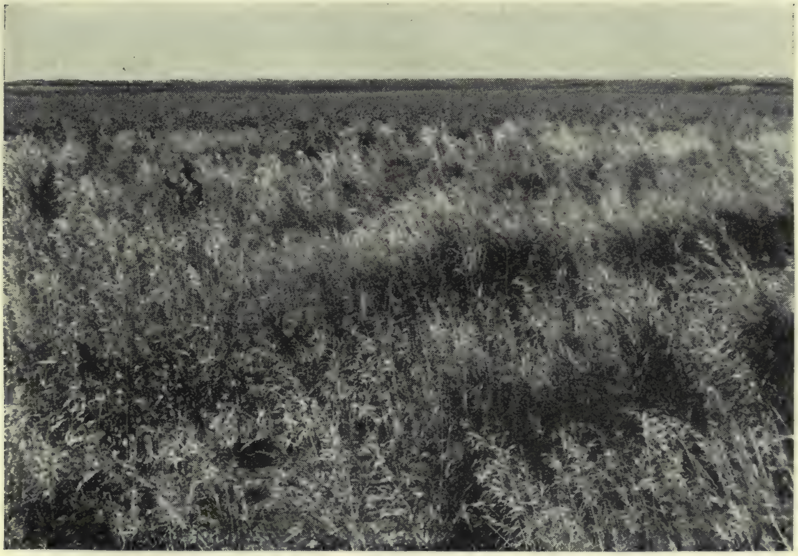

FIGURE 9.—Sudan and kafir growing about 18 months later on the area in figure 8.

REVEGETATION

It may prove beneficial to stabilize these sand-dune areas permanently by returning them to a native-grass cover. Two factors have been found to be important in the revegetation of such areas: (1) The development of an adequate cover in order to control soil shifting, and (2) the use of native species adapted to these conditions.

Results indicate that an adequate cover completely protects the soil by preventing shifting, accumulations, or removals. One of the best covers consists of native-weed species, such as Russian-thistle, and annual grasses. Grain sorghums may be efficient in controlling soil drifting if enough stalks and foliage are left to cover both the furrows and the ridges adequately (fig. 10).

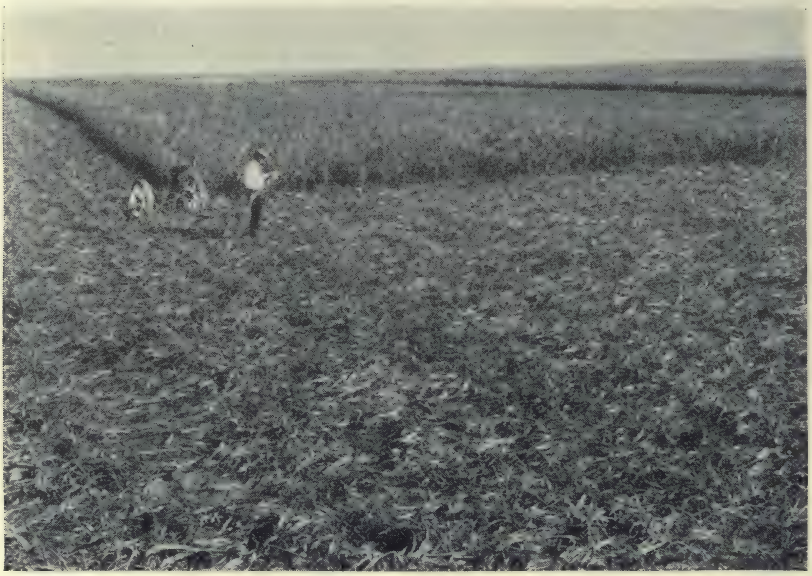

FIGURE 10.—The stalks and foliage of the hegari that is being mowed will adequately protect the soil from blowing.

The development of this cover is essential primarily because there must be sufficient litter or trash to prevent the shifting of soil materials during the blowing season. Furthermore, results on the sand-dune project and elsewhere show that the movement of soil particles tends to destroy grass seedlings by removing soil from around the roots, by covering the plants, and by the cutting action of the drifting sand.

Plants that are adapted to the existing conditions should be used for revegetation. On sand-dune areas effective sand-binding species should be used. A number of these, such as sand bluestem, sand reedgrass, Indian grass, side-oats grama, and sand dropseed, occur throughout the southern Great Plains. The most effective method yet found of developing a stand is spreading mature grass hay of these species over fields already protected by a cover. In June 1936. in order to seed a dune, mature sand reedgrass was spread over it. The dune covered 1.1 acres and was more than 16 feet high. Figure 11 shows a stand of seedlings in a blow-out in this dune in June 1937. By July 1937 a growth of sand reedgrass and Russian-thistle completely covered the area.

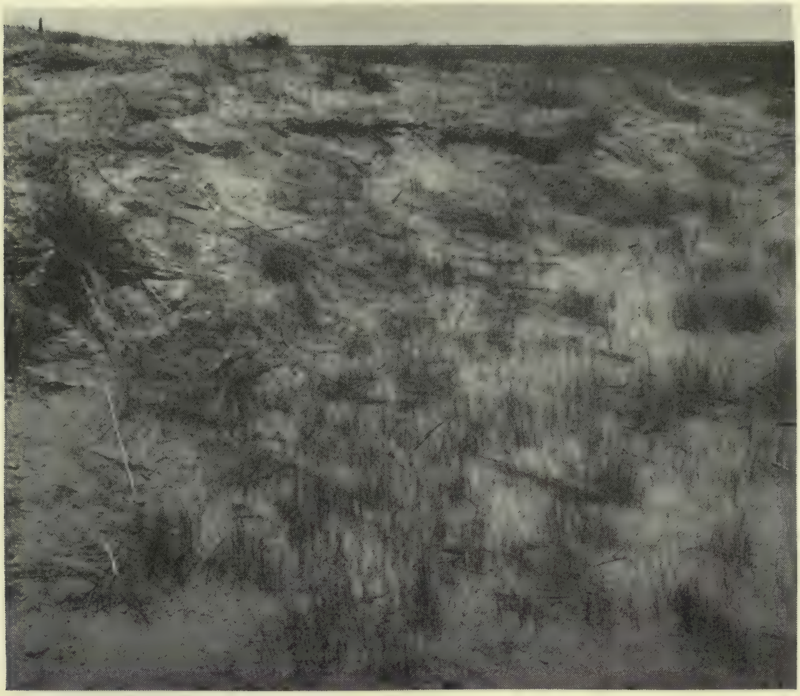

FIGURE 11.—A stand of seedlings that developed after mature sand reedgrass was spread in a blow-out.

RECOMMENDED LAND USE

Proper land use is essential if these areas are to be kept under control and cease to be a menace to surrounding land. It is much easier to prevent sand dunes from developing than it is to control them after they have developed. The better sandy areas, if farmed so as to prevent soil drifts, are entirely capable of producing good crops of grain sorghums and might well be used for this purpose. The more critical sites should be returned to grass. After they have been completely stabilized with a good grass cover, they can be used for controlled grazing.

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